Research-inspired Policy and Practice Learning in Ethiopia and the Nile region

Economic impacts of access to water and sanitation in Ethiopia:

Evidence from the Welfare Monitoring Surveys

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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.

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SIWI	Stockholm International Water Institute
WHO	World Health Organisation
WSS	water supply and sanitation

Executive Summary

The aim of this study is to explore the potential linkages between access to water and sanitation and growth-related indicators in Ethiopia. While the expected benefits from investments in water and sanitation on poverty are immense, there is still only a small (although growing) body of empirical evidence on the issue.

This study uses data from Ethiopia's Welfare Monitoring Surveys collected by the Central Statistics Agency in 1999/2000 and 2004/2005 to explore the links between access to water and sanitation and economic growth. Econometric analysis is used to examine the relationship between access to water and sanitation and the following factors: productive employment (used as a proxy for household income), enrolment of children in school, health status, and the self-reported food situation and overall welfare situation of households.

The main hypotheses are: (i) lower distances to drinking water have a positive impact on household income, because time saved in collecting water can be used for productive employment; (ii) lower distances to drinking water have a positive impact on school enrolment of children, because children's time is saved in collecting water; and (iii) improvements in the quality of water and sanitation sources reduce illness in adults and children, which in turn tends to raise productive employment and school enrolment.

The data indicate that there was a general improvement in access to improved water sources in Ethiopia from 2000–05. However, a majority of people in rural areas still used unimproved water sources in 2005. More than 73% of the households surveyed used fields or forest as toilets in 2000, and this proportion only slightly decreased by 2005, although it declined significantly in Addis Ababa. Overall there was an increase in the number of people that reported improvement in their food situation. Other findings were more mixed. Benishangul, Harari, Oromia and Amhara witnessed an increase in people in productive employment over the five year period, but the reverse happened in other regions. The proportion of children enrolled in school increased in most regions but declined significantly in Tigray, while all regions except Afar, Addis Ababa and Harari showed relative improvements in household health status.

Regression analyses were carried out at regional and zonal level to explore the links between these changes in water and sanitation access and changes in household welfare. A positive and statistically significant relationship is found between improvements in households' source of drinking water and improvements in households' self-reported food situations. In other words, households experiencing an improvement in their source of drinking water were more likely to report an improvement in their food situation, and less likely to report deterioration. One explanation for this finding is that an improvement in the quality of water reduces illness, which in turn tends to raise productive employment. This would tend to improve a household's food situation. However there remains a possibility that improvements in sources of drinking water are being driven by some other unobserved factor which also happens to be improving households' food situations.

No significant relationship is found between improvements in drinking water sources and households' overall welfare. This may be because a household's overall welfare situation is affected by a much wider range of factors, which obscures the contribution of improvements in sources of drinking water. For example this analysis finds that land ownership is a highly significant factor in household welfare. Changes in sanitation arrangements are found to have no relationship with

changes in households' food or welfare situations, and no significant relationship is found between distance to drinking water and either productive employment or school enrolment, although initial analysis at woreda level suggests that distance to water does significantly affect women's employment.

Altogether this analysis provides some limited evidence of significant economic benefits to improvements in access to drinking water and sanitation. However, the data used to conduct this study had a number of limitations, including that individual households could not be tracked over time and that data on incomes and on the time allocated by household members to different activities are not available. The apparent absence of stronger benefits from water and sanitation is therefore as likely to be the result of inadequacies in the survey data, as a reflection of an actual lack of economic benefits.

1 Introduction

1.1 Aims and objectives

The aim of this study is to explore the potential linkages between access to water and sanitation and growth-related indicators in Ethiopia. The analysis is based on data from the 1999–2000 and 2004–05 Welfare Monitoring Surveys carried out by the Ethiopian Central Statistics Agency. These surveys contain information on the different types or sources of drinking water and sanitation to which households have access, including their distance (in kilometres) from their source of drinking water. The surveys also contain information on a range of growth-related welfare indicators, including work status (e.g. whether productively employed or not), health status (e.g. whether ill recently), school enrolment (whether registered to attend school), and indicators of whether households' food and/or overall living standards have improved or deteriorated over the past year. Econometric analysis is used to examine the relationship between these two sets of variables, while controlling for other possible influences on growth and welfare.

The paper is organised as follows. The remainder of this section describes some of the existing empirical evidence on the economic impacts of access to water and sanitation. Section 2 then outlines the main hypotheses which the analysis in the paper sets out to test, while Section 3 outlines the econometric methods used. Section 4 then provides some basic descriptive information regarding the measures of access to water and sanitation, and the growth-related welfare indicators, analysed in the study, by year and by region. Section 5 then presents the results of the econometric analysis. Finally, Section 6 summarises the main findings, and discusses implications of the analysis and potential next steps.

1.2 Existing empirical evidence

It is often argued that investments in water and sanitation generate sectoral and cross–sectoral economic benefits. At an aggregate level, the benefits of water and sanitation related interventions include benefits for agricultural development and food production, industrial production, and cross-cutting benefits such as eco-system services and protection against floods and droughts. A recent study by Stockholm International Water Institute (SIWI) (2005) argues that investments in the water sector can generate economic benefits that considerably outweigh their costs, and make a significant contribution to human development. In addition, improved water resources management and water supply and sanitation (WSS) contribute significantly to increased production and productivity (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 as well as the 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.

While the expected benefits from investments in water and sanitation on poverty are immense, there is still only a small (although growing) body of empirical evidence on the issue. As is well-known, there is a positive relationship across countries between per capita income and access to water and sanitation (e.g. UNDP 2006: 35-36). However, while part of this relationship may reflect a causal effect of better access to water and sanitation on productivity and income, there are no studies which test this hypothesis directly. Some indirect evidence in support is provided by studies which find a positive relationship across countries between initial levels of health, and subsequent rates of economic growth (e.g. Sachs and Warner 1997; Barro and Sala-i-Martin 2005).[1] This is strong evidence to the extent that access to water and sanitation has a positive effect on health.[2] For more direct evidence however, we have to turn to more detailed studies at the country (or regional) level.

It is fairly well known that many people in developing countries, particularly women, spend a large amount of time collecting water: up to six hours a day according to one recent estimate (SIWI 2005: 14). There is also evidence that this limits the amount of time spent by women in productive employment. In rural Pakistan for example, Ilami and Grimard (2000) find a statistically significant negative relationship between time allocated by adult women to market-oriented wage employment and the distance to the nearest water source, controlling for other influences.[3] 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 of households that have access to safe water, across villages in rural Tanzania. The estimates control for various other influences on households' labour supply, including land availability, location, dependency ratios, education and availability of electricity.[4]

There is significant evidence from studies at the national (or regional) level 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.[5] More recently, estimates for Cameroon, Egypt, Peru, Vietnam and Uganda provided by Fuentes *et al.* (2006a), Egypt by Abou-Ali (2003), and India by Guillot and Gupta (2004), all show a strong relationship between better access to water and sanitation and lower infant mortality rates.[6] However, although it is plausible that the positive effect of water and sanitation 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 Cote 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 cent per year.

[2] The SIWI (2005) report, for example, argues that countries with access to improved WSS have significantly higher rates of economic growth than those without: an average of 3.7% per year compared to 0.1% per year. This finding, which is taken from Sachs (2001:23), in fact relates to differences in growth rates between poor countries with high and low rates of infant mortality.

[3] Market-oriented wage employment includes off-farm (wage) work as well as on-farm (unpaid) work; earlier analysis suggested that pooling of the data in this way was appropriate. The data were taken from the 1991 Pakistan Integrated Household Survey; around 43% of women in the sample reported some time spent in water collection.

[4] The data are obtained from the 2000/2001 Household Budget Survey of Tanzania. Around 10% of the households interviewed reported participating in off-farm wage employment, while around 40% reported having access to safe water.

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

[6] The studies by Fuentes et al. (2006a) and Abou-Ali (2003) use Demographic and Health Survey (DHS) data, while the study by Guillot and Gupta (2004) uses data from the 1998-99 National Family Health Survey. Other studies have examined the effects of access to water and sanitation on the incidence of diarrhoea, e.g. Fuentes et al. 2006b, which looks at 24 countries including Ethiopia (see Zwane and Kremer (2007) for a recent review of the evidence).

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.

2 Conceptual framework

This section describes in more detail the three main hypotheses tested in the paper.

The first hypothesis is that lower distances to sources of drinking water have a positive impact in the short-run on household income levels. This is derived from a standard household model, in which household members allocate their time between different activities, including wage labour, labour for own-enterprises (farm or non-farm), household production activities (e.g. looking after children, homework), and leisure. In such a model, a reduction in distance to water sources reduces the time spent collecting water, and in doing so frees up time which can be used instead for wage labour or labour for own-enterprises. This in turn raises household income (including the value of any own-production consumed directly).

The time-savings resulting from shorter distances to water sources are considered by the World Health Organisation (WHO) to represent the largest source of the overall income-related benefits from increased access to water and sanitation (Hutton and Haller 2004). Nevertheless, it is worth noting that such benefits are not guaranteed. A household might respond in other ways to lower distances to water sources: by taking the additional time freed up as increased leisure, housework, or time in school for children for example (see below). It could even be used simply to collect more water (i.e. make more trips). In such cases, observed household income would not increase, even though household welfare may increase. Alternatively, it could be that despite an increase in the amount of time spent in productive employment, effects on income are offset by a reduction in the returns to such employment due to the increase in labour supply.

A second hypothesis is that lower distance to the nearest water source has a positive impact in the short-run on enrolment of children in school. This hypothesis is derived from the same basic model outline above. In this case, the hypothesis is that less time spent collecting water by children frees up time which can be spent in school instead. This is especially important if children are the main household members involved in collection of water besides women.

The third and final hypothesis is that an improvement in the quality of water and sanitation sources reduces illness among children and adults, which also in turn tends to raise productive employment and enrolment of children in school. This may be due to various factors. First, less time spent ill frees up time to be used in productive employment and/or education. Second, better health raises productivity, the returns to working and access to employment, as in 'efficiency-wage' theories, therefore raising the probability of being in employment. Third, lower expected rates of mortality and/or morbidity rates raise the returns to investing in education, raising enrolment rates.

To summarise therefore, we expect: a) a negative relationship between distances to drinking water on the one hand, and household income and school enrolment on the other; and b) a positive relationship between the quality of water and sanitation sources on the one hand and household income and school enrolment on the other.

Two final points are worth stressing at the outset. The first is that our hypotheses relate mainly to the short-term benefits of investing in water and sanitation. There may well be additional benefits in the long-term. For instance, higher enrolment in school, as a result of shorter distances to water sources, and/or less illness among children, could eventually lead to a more educated and productive labour force, and higher economic growth. (For further discussion, including examples of other longer-term income benefits, see SIWI 2005:14-15.) We focus on short-run benefits mainly because we do not have necessary data to analyse potential long-run effects (our data span a four-year period only). The second point is that, with regard to water, our hypotheses relate to the impacts of improved access to drinking water, as opposed to water for agricultural purposes. This is again because we do not have the necessary data to analyse the productive impacts of water for agricultural uses.

3 Data methods

The analysis in the paper is based on data from the 1999–2000 and 2004–05 Welfare Monitoring Surveys collected by the Central Statistics Agency in Ethiopia. The 1999–2000 survey covered 25,917 rural and urban households, while the 2004–05 survey covered 36,353 rural and urban households. In both surveys, data collected was in regard to households' access to basic services including drinking water and sanitation. Both surveys also provide a series of indicators of household welfare, including health, education, nutrition, as well as certain self-reported indicators of living standards (e.g. whether a household considers it current welfare to be the same, worse, or better than twelve months ago).

To test the paper's hypotheses, our underlying approach is to estimate fixed-effects regressions of the form:

$$\Delta y_i = \alpha_0 + \alpha_1 \Delta d_i + \alpha_2 \Delta q_{Wi} + \alpha_3 \Delta q_{Si} + \upsilon_i \quad \textbf{(1)}$$

$$\Delta s_i = \beta_0 + \beta_1 \Delta d_i + \beta_2 \Delta q_{Wi} + \beta_3 \Delta q_{Si} + \varepsilon_i \quad \textbf{(2)}$$

where Δ indicates a change in each variable over some period of time, y_i is the income of each household, s_i is enrolment in school of children in each household, d_i is the distance of each household from its nearest water source, q_{Wi} is some measure of the quality of the water source, q_{si} is some measure of the quality of the sanitation source, υ_i reflects all other influences on changes in household income over time, and ε_i reflects all other influences on changes in school enrolment over time.

The advantage of this approach is that it controls for any unobserved time-invariant factors which would otherwise cause spurious correlation between income or school enrolment, and distance to water or quality of water and sanitation. We are not able to estimate standard fixed-effects regressions at the household-level, since the 1999–2000 and 2004–05 surveys do not represent a panel: they do not provide information on the same households in each year. However, we are able to estimate two 'second-best' sets of regressions. The first is an adapted household-level fixed-effects regression, and the second is an area-level fixed-effects regression.

3.1 Household-level fixed effects approach

The household-level fixed-effects regression utilises the information contained in the two surveys on households' own assessment of whether their situation has changed, as compared with their situation one year ago. This information is available for both a household's food situation, and its overall welfare situation. These two indicators provide proxy measures of Δy_i in equation (1), with a time period corresponding to one year. They are of course very imperfect proxies, for at least three reasons. First, household responses are reported in categorical form (e.g. much better, a little better, no change etc.) rather than in continuous units; second, each may be subject to recall bias; and third, the link between a household's income and its overall food or welfare situation is by no means perfect, nor is it automatic. Nevertheless, they do at least provide some indication as to whether a household's income has changed, and by how much, in comparison with one year ago.

The household-level fixed-effects regressions also utilise the information in the surveys regarding households' sources of drinking water and sanitation, both at the time of the survey and one year previously. In each case, this information is reported in terms of categories (e.g. piped, well, river etc.), which we divide into high-quality and low-quality. This is done as follows:

- higher-quality water source: tap (house, compound or out of compound) or protected well or spring;
- lower-quality water source: unprotected well or spring, rain water or river/lake/pond;
- higher-quality sanitation source: flush toilet (shared or private) or pit latrine (shared or private);
- lower-quality sanitation source: household utensils, field or forest.

Given these definitions, we are able to then construct variables indicating whether household sources of drinking water and sanitation have improved or deteriorated over the previous year. These variables provide proxy indicators for the variables Δq_{Wi} and Δq_{Si} in equation (1). Unfortunately however, neither survey provides information on households' distance from their nearest water source at the time of the survey and one year previously. This means that we are unable to measure the variable Δd_i in equation **(1)**; it instead becomes part of the residual term, $\Delta \upsilon_i$.

We include three sets of control variables in the household-level fixed-effects regressions. The first is a set of household 'shock' variables, each of which indicates whether a household has experienced a particular adverse event during the past 12 months. These are: death of a household member; illness of a household member; loss of job of a household member; food shortage; drought; flood; crop damage; loss or death or livestock; price shock; and other. The second is a set of household livelihood variables, indicating the main source of each household's income. A separate dummy variable is included for sixteen different sources: these include own agricultural enterprise, non-agricultural own enterprise, gifts and remittances, wages, and various others. The third is a set of dummy variables for each district (wereda), which are included to capture determinants of household food or overall welfare status which are common to geographical districts, such as weather conditions.

Finally, we limit the analysis to the 2004 survey only, since the data contained in this survey have two significant advantages over those contained in the 2000 survey in terms of implementing this approach. First, in the 2004 survey there are five possible responses to the questions relating with how the household's situation is different now compared with 12 months ago, compared to only three in the 2000 survey. Second, there is extensive information in the 2004 survey (but not in the 2000 survey) on the different types of shocks that households have experienced over the past 12 months, which serve as control variables in the regression.

To summarise, the household-level fixed-effect regressions take the form:

$$\Delta \hat{y}_i = \alpha_0 + \alpha_1 D_{1i} + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \alpha_4 D_{4i} + \alpha_5 X_i + \alpha_5 Z_i + \alpha_5 W_i + \Delta \varepsilon_i \qquad \textbf{(3)}$$

where $\Delta \hat{y}_i$ indicates the change in a household's position in comparison with one year ago, D_{1i} is a dummy variable indicating whether a household has experienced an improvement in its water source over the past year, D_{2i} indicates whether a household has experienced a deterioration in its water source over the past year, D_{3i} indicates whether or not a household has experienced an improvement in its sanitation source over the past year, D_{4i} indicates whether a household has experienced a deterioration in its sanitation source over the past year, X_i is the set of household shock variables, Z_i is the set of household livelihood characteristics, and W_i are the district (woreda) level fixed effects.

Two separate regressions are run, first using the information on household positions in food terms, and then using the information on household positions in overall terms. The regressions themselves are run using the method of ordered probit analysis. Note that we are unable to estimate a similar regression corresponding to equation (2), since there is no household-level information on whether a household's schooling situation has changed over the past year.

3.2 Area-level fixed-effects regression

The second main approach used in the paper is to estimate area-level fixed-effects regressions. This is possible since it is possible to match, if not households, then at least geographical areas between the two surveys. In particular, we estimate regressions of the form:

$$\Delta \bar{y}_j = \alpha_0 + \alpha_1 \Delta \bar{d}_j + \alpha_2 \Delta z_j + \upsilon_j \qquad \textbf{(4)}$$

$$\Delta \bar{s}_j = \beta_0 + \beta_1 \Delta \bar{d}_j + + \beta_2 \Delta z_j + \varepsilon_j \qquad \textbf{(5)}$$

where $\bar{y}_j$ is the average income of each area (e.g. a zone or a district), $\bar{s}_j$ is average enrolment in school of children in each area, $\bar{d}_j$ is the average distance of households from their nearest water source in each area, z_j is a set of control variables, υ_j reflects all other influences on changes in average income in each area over time, ε_j reflects all other influences on changes in school enrolment in each area over time, and Δ indicates the change in a variable over some period of time.

In these regressions, average distance from water sources is measured in kilometres. Data on income are not available in both surveys, so we instead use a proxy, which is the proportion of household members who are engaged in 'productive' (i.e. direct, income-generating) employment. This is an imperfect proxy, since it will not capture the effects of reductions in distance to water sources on the amount of time that household members spend in productive employment, but is available in both surveys and is the best proxy available. We distinguish between productive employment among men and women, since if women are mainly involved in water collection, we would expect distance to water source to have a much greater impact on their employment, compared to that of men.

For enrolment, we calculate the proportion of household members aged 10-14 who are registered to attend school. This is also an imperfect proxy, since registration tells us nothing about actual attendance, completion and/or drop-out rates, but again it is the best proxy available. For control variables, we include measures of household distance from other facilities and services, namely: food market, post office, primary school, secondary school, bus or taxi service, all weather road, dry weather road, telephone booth and milling house. These are likely to be correlated with distance from water sources, and may also affect household income and school enrolment: they are included therefore to reduce the possibility of spurious correlation.

For the area-level fixed-effects regressions, a key issue is the geographical unit at which the analysis is to be varied out. In this paper, the regressions are done at the level of zones. The advantage of this is that zone-level data are based on more sample observations, which lowers the amount of sampling error in the zone-level averages. There are two disadvantages however. The first is that the number of zones is not very large (around 50 zones can be matched between the two surveys), which limits the number of observations in the fixed-effects regression. The second is that each zone is typically quite heterogeneous, which raises the amount of sampling error in the zone-level averages.

For this reason, it would be interesting to compare the results of the zone-level analysis with results from district (wereda) level analysis. This would increase the sample size in the fixed-effects regression from around 50 to 400 observations. Doing this would require matching up districts between the 2000 and 2004 surveys, which unfortunately is not currently possible (the Ethiopian Central Statistics Agency are not prepared to release the codes for each district used in the Welfare Monitoring Surveys).

4 Descriptive statistics from the Welfare Monitoring Surveys

4.1 Access to water

In this section we describe the situation of access to water supply during 1999–2000 and 2004–05 in the 10 regions of the country. By doing so, we document the differences in level of access, by source type, and changes in access between the two periods.

Household access to different sources of drinking water by region is shown in Tables 4.1 and 4.2. The possible sources of water reported in the survey are: tap in household, tap in compound, both shared and private, protected well/spring, unprotected spring/well, rain water (wet season only) and ponds, lakes and rivers. From the results we observe that:

- lower quality or 'unimproved' sources (unprotected spring/well, rain water and ponds, lakes and rivers) typically provide for more than half of the water to households, in both periods;
- however, there is significant (see reported test statistics in the table below) improvement in access to higher quality or 'improved' water sources in 2004–05 compared with 1999–2000 across the regions;
- there are limited differences in sources of drinking water between the wet and dry season, save source from rain water;
- regional disparities in terms of access to improved water sources are not that big. Even for Addis Ababa, the capital, more than 50 percent of the households obtained their water from unprotected sources in 1999. However, there is a significant improvement in access to improved water sources in the capital between the two surveys; and
- in 1999–2000 and 2004–05 there was a significant difference in access to water supply between rural and urban households both in the dry season and wet season. The summary and test results for the 1999–2000 survey are reported in Annex I.

Table 4.1: Sources of drinking water in the dry season, 1999–2000 and 2004–05 (% of households)

	1999–2000							2004–05						
Region	**Tap in household**	**Tap in compound, private**	**Tap in compound, shared**	**Tap outside compound**	**Protected well/ spring**	**Unprotected well/spring**	**River, lake, pond**	**Tap in household**	**Tap in compound, private**	**Tap in compound, shared**	**Tap outside compound**	**Protected well/ spring**	**Unprotected well/ spring**	**River, lake, pond**
Tigray	0.1	3.0	1.0	21.9	14.7	21.1	38.2	1.9	7.3	8.3	22.6	16.9	21.9	21.1
Afar	0.2	4.2	1.1	20.7	15.7	22.4	35.7	1.9	10.2	7.9	30.0	4.4	12.8	32.8
Amhara	0.2	2.8	1.0	20.9	14.4	20.4	40.3	1.5	6.1	6.5	17.7	10.6	34.5	23.1
Oromia	0.1	2.9	1.1	20.2	14.6	21.3	39.9	1.1	6.0	4.8	20.4	9.8	32.5	25.4
Somali	0.3	5.2	1.5	23.9	14.2	20.2	34.6	0.7	3.0	5.2	30.3	7.0	21.5	32.3
Benshangul	0.3	3.0	1.2	19.9	13.9	20.5	41.2	0.7	1.4	1.4	13.3	15.7	20.2	47.3
SNNPR	0.1	2.0	0.9	19.7	14.8	21.8	40.7	0.6	2.5	2.3	15.6	12.5	35.7	30.9
Gambela	0.6	7.2	1.2	24.9	13.7	17.9	34.5	-	-	-	-	-	-	-
Harari	0.2	7.8	1.3	23.4	14.2	19.5	33.6	0.9	7.0	15.9	16.4	30.4	23.9	5.5
Addis Ababa	0.2	4.5	1.4	25.1	15.9	21.0	31.9	4.3	33.8	23.9	30.5	2.7	3.7	1.2
Dire Dawa	0.5	6.2	1.6	24.6	14.1	18.5	34.5	1.5	8.2	10.6	53.3	13.7	12.3	0.4

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

Test results of equality in type of access between 2000 and 2005: Pearson chi2 (64) = 208.3569 Pr = 0.000

Table 4.2: Sources of drinking water in the wet season, 1999–2000 and 2004–05 (% of households)

	1999–2000								2004–05							
Region	**Tap in household**	**Tap in compound, private**	**Tap in compound, shared**	**Tap outside compound**	**Protected well/ spring**	**Unprotected well/spring**	**Rain water**	**River, lake, pond**	**Tap in household**	**Tap in compound, private**	**Tap in compound, shared**	**Tap outside compound**	**Protected well/ spring**	**Unprotected well/ spring**	**Rain water**	**River, lake, pond**
Tigray	0.1	3.0	1.0	13.8	10.3	20.7	0.5	50.5	2.0	7.1	8.6	20.4	14.5	18.5	2.1	26.9
Afar	0.2	4.2	1.0	12.6	11.5	22.0	0.7	47.7	1.7	10.2	8.0	28.8	3.9	10.1	0.3	37.1
Amhara	0.2	2.8	1.0	13.1	9.5	20.2	0.6	52.6	1.6	6.0	6.6	18.0	10.0	34.0	0.9	22.9
Oromia	0.2	2.8	1.1	12.6	9.4	21.1	0.6	52.3	1.2	5.9	4.8	17.9	8.8	32.8	2.1	26.5
Somali	0.4	5.2	1.5	16.5	11.5	20.2	0.6	44.2	0.7	3.3	5.5	26.5	4.6	18.6	1.2	39.6
Benshangul	0.3	2.9	1.2	13.3	9.2	20.2	0.6	52.4	0.5	1.6	1.4	10.4	16.1	19.4	2.8	47.9
SNNPR	0.1	2.0	0.9	11.9	8.8	21.5	0.5	54.3	0.7	2.5	2.4	14.3	12.3	36.7	0.7	30.3
Gambela	0.6	7.3	1.1	15.8	12.4	17.8	0.3	44.8	-	-	-	-	-	-	-	-
Harari	0.2	7.8	1.3	16.5	9.7	19.4	0.5	44.5	1.1	7.5	16. 7	16.2	26.6	22.3	3.8	5.8
Addis Ababa	0.1	4.5	1.4	16.9	15.3	20.7	0.7	40.4	4.3	33.7	23.7	30.4	2.4	3.5	1.0	1.0
Dire Dawa	0.6	6.2	1.5	16.2	11.5	18.3	0.4	45.3	1.2	8.2	10.9	53.0	14.0	12.0	-	0.7

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

Test results of equality in type of access between 2000 and 2005: Pearson chi2 (49) = 185.8993 Pr = 0.000

Tables 4.3 and 4.4 show data from the 2004 survey on changes to households' water sources, over the last 12 months. The rows in the tables show the percentage of households using each type of water source in the year of the survey. The columns then show the percentage of households using each type of water source 12 months previously. Thus the households shown in the diagonal element of the table correspond to those households which did not change their water source compared with 12 months previously, whereas the households shown in the off-diagonal cells in the table did change their water source.

Table 4.3: Drinking water sources in the rainy season, 2004 (% of all households)

	Source of water, 12 months previously								
Source of water, year of survey	**Tap inside house**	**Tap in compound, private**	**Tap in compound, shared**	**Tap outside compound**	**Protected well or spring**	**Unprotected well or spring**	**Rain water**	**River, lake or pond**	**Total**
Tap inside house	0.9	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.0
Tap in compound, private	0.0	3.0	0.1	0.2	0.0	0.0	0.0	0.0	3.3
Tap in compound, shared	0.0	0.0	2.4	0.1	0.0	0.0	0.0	0.0	2.6
Tap outside compound	0.0	0.1	0.2	13.2	0.1	0.4	0.0	0.5	14.4
Protected well or spring	0.0	0.0	0.0	0.0	10.7	0.7	0.0	0.3	11.8
Unprotected well or spring	0.0	0.0	0.0	0.1	0.3	35.8	0.0	0.3	36.5
Rain water	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	1.5
River, lake or pond	0.0	0.0	0.0	0.1	0.1	0.1	0.0	28.6	29.0
Total	1.0	3.2	2.7	13.8	11.3	36.9	1.5	29.7	100.0

Notes: Figures include all households existing 12 months ago and reporting their water source in the year of the survey and 12 months previously. Results are calculated using the sample weights.

Source: 2004 Welfare Monitoring Survey.

Overall, Table 4.3 shows that 3.9% of households changed their source of water in the rainy season over the 12-month period: 1.9% of all households witnessed an improvement in their rainy season water source, while 0.7% witnessed deterioration.[7] Similarly, Table 4.4 shows that 4.3% of households changed their source of water in the dry season over the previous 12

7 Thus a further 1.3% of households changed their water source, but not in such a way as to be classified as an improvement or deterioration, according to our definitions.

months: 1.9% of households witnessed an improvement in their dry season water source, while 0.6% witnessed deterioration.[8] We look at the possible effects of these changes in the econometric analysis reported in Section 5.2.

Table 4.4: Drinking water sources in the dry season, 2004 (% of all households)

	Source of water, 12 months previously								
Source of water, time of survey	**Tap inside house**	**Tap in compound, private**	**Tap in compound, shared**	**Tap outside compound**	**Protected well or spring**	**Unprotected well or spring**	**Rain water**	**River, lake or pond**	**Total**
Tap inside house	0.8	0.0	0.0	0.1	0.0	0.0	-	0.0	0.9
Tap in compound, private	0.0	3.1	0.1	0.2	0.0	0.0	-	0.0	3.3
Tap in compound, shared	0.0	0.0	2.4	0.1	0.0	0.0	-	0.0	2.6
Tap outside compound	0.0	0.1	0.1	14.7	0.1	0.4	-	0.4	15.8
Protected well or spring	0.0	0.0	0.0	0.1	11.7	0.7	-	0.3	12.8
Unprotected well or spring	0.0	0.0	0.0	0.1	0.2	35.9	-	0.3	36.6
Rain water	-	-	-	-	-	-	-	-	-
River, lake or pond	0.0	0.0	0.0	0.1	0.1	0.1	-	27.7	28.0
Total	0.8	3.2	2.7	15.3	12.2	37.1	-	28.7	100.0

Notes: See Table 1.
Source: 2004 Welfare Monitoring Survey.

4.2 Access to sanitation

In this section we describe access to sanitation during 1999–2000 and 2004–05 in 10 regions of the country, and in particular access, to toilet and solid waste disposal mechanisms. The classification for toilet facility consists of: flush toilet (private), flush toilet (shared), pit latrine (private), pit latrine (communal), container, field/forest and others. The categories for solid disposal included use of disposal vehicle, use of container, use of dug outs, throwing away, use as

[8] It is worth noting that the vast majority (86%) of households witnessing an improvement in their water supply in the rainy season also witnessed an improvement in the dry season, and vice versa (81%). Similarly, the vast majority (70%) of households witnessing a deterioration in their water supply in the rainy season also witnessed a deterioration in the dry season, and vice versa (86%).

fertilizer, burning and other ways. The summary results by region are reported in Tables 4.5 and 4.6 respectively.

Accordingly, more than 73% of the households in all the regions used field/forest as toilets in 1999–2000 which could have serious environmental and health consequences. This has slightly gone down in 2004–05, but still field/forests are used as a major toilet source in all regions of Ethiopia. We see significant reduction in the role of fields and forest in 2004–05 only in Addis Ababa, where many shared pit latrines have been constructed in the mean time. Overall our non-parametric test results indicate that there is significant difference in access to toilet facilities between 1999–2000 and 2004–05 across the regions.

As far as access to solid waste disposal facilities are concerned, in 1999–2000, in almost all regions use of dug outs was the dominant solid waste disposal strategy. This seems to have changed in favour of using waste as fertilizer in 2004–05. In the urban areas, such as Addis Ababa and Dire Dawa, use of vehicle and containers has increased respectively. Similarly, our test results reject the equality of access in these services between the two periods.

Table 4.5: Sources of sanitation, 1999–2000 and 2004–05 (% of households)

	1999–2000							2004–05						
Region	**Flush toilet (private)**	**Flush toilet (shared)**	**Pit latrine (private)**	**Pit latrine (shared)**	**Container**	**Field/forest**	**Other**	**Flush toilet (private)**	**Flush toilet (shared)**	**Pit latrine (private)**	**Pit latrine (shared)**	**Container**	**Field/forest**	**Other**
Tigray	0.4	0.3	11.8	8.3	0.1	79.0	0.1	3.5	4.8	9.5	8.9	0.4	72.9	0.1
Afar	0.5	0.4	12.4	8.4	0.1	78.2	0.1	1.7	1.5	12.2	11.7	0.3	72.4	0.2
Amhara	0.4	0.2	11.0	7.9	0.0	80.4	0.1	1.1	1.7	12.0	11.8	0.3	73.0	0.2
Oromia	0.4	0.3	11.3	8.0	0.0	79.9	0.1	1.5	1.1	20.2	11.9	0.2	64.9	0.1
Somali	0.5	0.5	13.5	9.9	0.1	75.4	0.1	0.8	1.2	12.1	21.7	0.2	63.9	0.1
Benshangul	0.3	0.4	10.9	8.9	0.1	79.2	0.1	0.8	0.5	24.9	20.9	0.1	52.5	0.2
SNNPR	0.4	0.2	10.9	7.9	0.0	80.4	0.1	1.8	0.6	42.6	12.3	0.1	42.5	0.1
Gambela	0.4	0.4	13.7	10.1	0.1	75.3	0.1	-	-	-	-	-	-	-
Harari	0.5	0.3	16.1	9.9	0.0	73.2	0.1	3.8	2.3	18.0	28.1	0.3	46.5	0.9
Addis Ababa	0.3	0.5	12.8	11.5	0.1	74.7	0.1	9.8	6.6	24.7	45.0	0.9	12.2	0.9
Dire Dawa	0.6	0.5	14.0	10.7	0.1	74.1	0.1	2.1	1.6	22.9	30.3	0.2	43.0	-

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

Test results of equality of access in toilet facilities: Pearson chi2 (49) = 151.5604 Pr = 0.000.

Table 4.6: Sources of waste disposal, 1999–2000 and 2004–05 (% of households)

	1999–2000							2004–05						
Region	Waste disposal vehicle	Use container	Use dugouts	Throw away	Use as fertilizer	Burn	Other	Waste disposal vehicle	Use container	Use dugouts	Throw away	Use as fertilizer	Burn	Other
Tigray	3.4	7.8	58.6	26.2	3.5	0.5	0.0	12.6	6.2	10.4	37.2	31.0	2.1	0.5
Afar	4.3	6.9	58.6	26.0	3.8	0.5	0.0	0.3	3.9	4.9	67.3	5.2	18.4	0.2
Amhara	3.1	7.8	59.5	26.0	3.3	0.4	0.0	1.9	6.8	5.7	33.8	46.3	5.1	0.5
Oromia	3.0	7.2	59.3	27.0	3.2	0.3	0.0	2.2	2.7	8.4	37.6	41.4	6.7	1.0
Somali	4.9	7.8	57.4	24.7	4.5	0.7	0.0	10.1	1.2	3.1	68.1	4.1	13.4	0.1
Benshangul	3.0	7.6	59.7	26.7	2.3	0.7	0.0	0.3	1.0	15.2	51.6	27.3	4.0	0.5
SNNPR	2.2	8.1	59.5	27.5	2.5	0.3	0.0	0.5	2.0	9.7	23.0	58.4	5.7	0.7
Gambela	5.2	8.8	57.4	22.4	5.6	0.7	0.0	-	-	-	-	-	-	-
Harari	5.3	8.8	57.3	24.3	3.2	1.0	0.0	2.5	19.4	19.4	23.1	26.3	6.6	2.8
Addis Ababa	6.1	5.9	57.2	23.0	7.1	0.7	0.0	25.2	35.8	3.5	13.9	2.8	8.4	9.5
Dire Dawa	5.5	8.3	57.4	23.6	4.4	0.8	0.0	0.3	31.8	5.7	43.0	11.3	7.3	0.4

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

Test results of equality of access in waste disposal: Pearson chi2 (42) = 224.3341 Pr = 0.000.

Finally, Table 4.7 shows information contained in the 2004 survey about changes in households' sources of sanitation over the previous 12 months. Once again, the rows in the table show the percentage of households using each type of sanitation in the year of the survey, while the columns show the percentage using each type 12 months previously. Overall, the table shows that 7.3% of households changed their source of sanitation over the period. Of these, 5.6% of households witnessed an improvement in their source of sanitation over the period 2003-04, while 1.0% witnessed deterioration. We again look at the possible effects of these changes in the econometric analysis reported in Section 5.2.

Table 4.7: Sources of sanitation, 2004 (% of all households)

	Source of sanitation, 12 months previously							
Source of sanitation, survey year	Flush toilet, private	Flush toilet, shared	Pit latrine, private	Pit latrine, shared	House-hold utensils	Field or forest	Other	Total
Flush toilet, private	1.2	0.0	0.0	0.0	0.0	0.2	0.0	1.4
Flush toilet, shared	0.0	0.9	0.0	0.0	0.0	0.0	0.0	1.0
Pit latrine, private	0.0	0.0	14.6	0.3	0.0	4.4	0.0	19.3
Pit latrine, shared	0.0	0.0	0.2	7.4	0.0	0.9	0.0	8.5
Household utensils	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2
Field or forest	0.0	0.0	0.7	0.3	0.0	68.3	0.0	69.3
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
Total	1.2	1.1	15.5	8.0	0.2	73.8	0.2	100.0

Notes: The figures include all households which existed 12 months ago and which reported their source of sanitation both in the year of the survey and 12 months previously. Results are calculated using survey weights.

Source: 2004 Welfare Monitoring Survey.

4.3 Welfare indicators

While the changes in access to water and sanitation have been presented in the previous sections, we now summarize the information relating to people's welfare status. The main welfare measures considered are:

- **work status**: whether in productive (direct, income-generating) employment;
- **school enrolment**: whether registered to attend school;
- **health condition**: absence from illness in the last three months;

- **food situation**: whether the household's food situation has improved, deteriorated or remained the same in comparison with one year previously;
- **overall living condition**: whether the household's overall living condition has improved, deteriorated or remained the same in comparison with one year previously; and
- whether the household is able to raise 100 Birr in a week to overcome unforeseen events.

The results for work status are shown in Table 4.8. In 1999–2000 between 46 and 63 percent of respondents in the various regions reported being engaged in productive employment, in comparison to between 35 and 68 percent in 2004–05. Overall, there was a slight tendency towards an increase in productive employment. However, in five regions we found a significant decrease in productive engagement in contrast to the three regions that showed significant increase in employment. There was no significant change in Harari in terms of productive employment. One can also see that productive employment was lower in Addis Ababa and Dire Dawa (cities, urban) than in the other regions (rural). There is strong urban-rural divide in rates of productive employment.

Table 4.8: Productive employment (% of members 10 years and above)

Region	1999–2000	2004–05	Proportional test P > |z|
Tigray	51.9	35.2	0.0000
Afar	60.8	53.1	0.0000
Amhara	59.6	61.3	0.0102
Oromia	56.6	60.4	0.0000
Somali	54.9	47.6	0.0000
Benishangul	59.3	67.5	0.0000
SNNPR	62.7	60.8	0.0021
Gambela	47.2	-	-
Harari	47.2	48.3	0.5241
Addis Ababa	46.2	37.2	0.0000
Dire Dawa	57.3	49.7	0.0000

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

As far as school enrolment is concerned, there is a significant increase in most of the regions over the period. Exceptions are Tigray and Afar that showed significant decline in gross enrolment rates and Harari where there is no significant change. In 1999–2000, the proportion of people enrolled in school ranged from 15 to 37 percent, while in 2004–05 it ranged from 17 to 35 percent (see Table 4.9).

Table 4.9: School enrolment (% of children aged 5 years and above)

Region	1999/2000	2004–05	Proportional test P > |z|
Tigray	27.1	20.1	0.0000
Afar	12.6	17.8	0.0000
Amhara	21.4	22.8	0.0037
Oromia	21.6	23.4	0.0000
Somali	15.4	18.7	0.0001
Benishangul	28.5	28.3	0.8264
SNNPR	18.8	24.3	0.0000
Gambela	36.7	-	-
Harari	25.3	27.4	0.1240
Addis Ababa	34.8	34.8	1.0000
Dire Dawa	20.3	28.2	0.0000

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

In terms of health, there appears to be some improvement in almost all the regions. The exceptions were Afar and Addis Ababa, where is no significant reduction in the percentage of household members who reported being sick (see Table 4.10).

Table 4.10: Health status (% of household members who reported being sick)

Region	1999–2000	2004–05	Proportion test P > |z|
Tigray	38.6	28.2	0.0000
Afar	29.9	30.6	0.5029
Amhara	26.4	22.6	0.0000
Oromia	25.3	23.7	0.0000
Somali	30.5	20.8	0.0000
Benishangul	37.7	33.1	0.0000
SNNPR	25.0	23.5	0.0000
Gambela	36.7	-	-
Harari	27.0	26.7	0.7883
Addis Ababa	15.5	14.9	0.2537
Dire Dawa	38.9	22.2	0.0000

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

As far as the food situation is concerned, between 24 and 28 percent of households in 1999–2000 reported an improvement, between 36 and 39 percent reported deterioration, and between 35 and 38 percent reported no change. In 2004–05, between 18 and 41 percent of households reported an improvement, between 19 and 45 percent reported deterioration, while between 30 and 57 percent reported no change (see Table 4.11). From these results one could infer that the food situation has witnessed some improvement, both in terms of the number of people that reported improvement and people who maintained the same level of food situation.

Table 4.11: Changes in household food situations over past 12 months (% of households)

	1999–2000			2004–05		
Region	Worse	Same	Better	Worse	Same	Better
Tigray	38.4	36.6	25.1	32.2	44	23.6
Afar	38.5	36.2	25.4	19.3	39.3	41.2
Amhara	37.9	37.6	24.5	34.3	44.1	21.2
Oromia	38.3	36.7	25	36.2	30.5	32.9
Somali	38.1	36.4	25.6	44.8	35.8	19.1
Benshangul	38.3	36	25.7	32.8	37.7	29.3
SNNPR	37.6	36.8	25.7	43	28.8	27.8
Gambela	38.5	37.7	23.8	0	-	0
Harari	36.4	35.2	28.4	26.3	43.6	29.3
Addis Ababa	38.1	37.8	24	25.4	56.5	17.7
Dire Dawa	38.8	35.1	26.1	31	38	30.4

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

Regarding the overall welfare situation (see Table 4.12), between 24 and 44 percent of the households reported deterioration in 1999–2000, while between 21 and 43 percent reported an improvement. In 2004–05, between 19 and 42 percent of the households reported deterioration, while between 22 and 41 percent reported an improvement.

It is worth noting that there is a close correspondence between the household changes in food status on the one hand, and changes in overall welfare status on the other. For example, of the households reporting themselves worse off in food terms in 2004, 79% also reported themselves worse off in overall terms. Similarly, of the households reporting themselves better off in food terms in 2004, 81% also reported themselves better off in overall terms.

Table 4.12: Changes in overall welfare situation over past 12 months (% of households)

	1999–2000			2004–05		
Region	Worse	Same	Better	Worse	Same	Better
Tigray	44.4	34.4	21.2	31.1	45.8	22.8
Afar	44.4	34.4	20.2	19.3	39.9	40.8
Amhara	40.5	32.3	27.2	32.1	42.7	23.9
Oromia	38.2	25.2	36.5	35.1	28.5	36.2
Somali	43.6	23.5	32.9	42.1	34.6	22.1
Benshangul	35.1	26.9	37.7	30.2	37.4	32.2
SNNPR	42.6	25.9	31.4	39.7	29.2	30.9
Gambela	24.3	34.4	41	-	-	-
Harari	25.2	31.7	43	27.5	33.5	38.3
Addis Ababa	27.3	39.9	32.8	29.4	48.9	21.5
Dire Dawa	32.9	32.4	34.6	34.3	32.5	32.8

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

Finally, the proportion of households that reported to have the ability to raise 100 Birr in a week to overcome unforeseen events ranged from 48 to 78 percent in 1999–2000, but in 2004–05 the range is between 48 to 72 percent (see Table 13). This may imply that more households feel cash-constrained in 2004–05 compared to 1999–2000 despite the reported expansion of micro finance services in the country (see Annex 1).

Table 4.13: Ability to get 100 birr (% of households)

Region	1999–2000	2004–05	Proportion test P > |z|
Tigray	69.5	61.5	0.0000
Afar	68.7	61.7	0.0007
Amhara	60.2	59.9	0.7747
Oromia	66.8	61.9	0.0000
Somali	71.4	59.2	0.0000
Benishangul	53.2	61.1	0.0000
SNNPR	75.8	71.9	0.0000
Gambela	77.6	-	
Harari	76.0	68.7	0.0030
Addis Ababa	68.6	47.7	0.0000
Dire Dawa	48.2	56.6	0.0017

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

5 Econometric results

This section presents the results of the econometric analysis. It is divided into three sections. Section 5.1 first provides some initial exploratory analysis of the possible effects of access to water and sanitation on changes in households' (self-assessed) food situations and overall living standards. This analysis is not directly linked to the underlying conceptual framework, but is designed instead to test for patterns in the data which might otherwise go unnoticed. Section 5.2 then presents the results of the household-level fixed effects regressions described in Section 3.1. Finally, Section 5.3 presents the results of the zone-level fixed-effects regressions described in Section 3.2.

5.1 Initial results

In this section we provide some initial exploratory analysis of the possible effects of access to water and sanitation. We regress the two indicators of self-reported changes in the household situation (food situation and overall welfare situation) over the previous year on the household size, land ownership, a set of measures of access to water and to sanitation, and rainfall conditions. The dependent variables are multiple ordinal responses, the responses being much worse (=1), little worse (=2), same (=3) little better (=4) and much better (=5). Accordingly, we used ordered probit models to estimate these linkages. The analysis here is based on the 2004 survey only.

The results for food situation are presented in Table 5.1. In this case, the probability of the food situation being better is found to be positively associated with land ownership at 1% level of significance. As is well known land is one the most important productive assets in rural economies such as Ethiopia, so it is not surprising that households that have land are found to have better welfare than households without. Likewise, households that indicated to have faced rainfall shortage were found to be more likely to be worse off, at 1% level of significance. This also points out to the reliability of agricultural production on rainfall variability. Family size was also found to significantly, at 10% level, and negatively influence household welfare.

Looking into the influence of current access on the perceived food situation of households, we found that households that have access to unprotected wells/springs and unprotected pond/river/pond during the wet and dry season are more likely to be worse off in comparison with one year ago. Similarly, households that dispose their waste in dug outs are found to have a higher perceived food situation in comparison with one year previously.

The results for overall welfare situations are shown in Table 5.2. The results are very similar to those in Table 5.1. In particular, the probability of an improvement is positively associated with land ownership again at 1% level of significance. Likewise, households that indicated to have faced rainfall shortage were found to be more likely to be worse off, which again points to the reliability of agricultural production on rainfall variability. Family size is found to be associated with lower perceived food situation, albeit at 10% level of significance. As far as access to water and sanitation is concerned, we found that households that have unprotected wells/spring and unprotected pond/river/pond as water source during the wet and dry season are more likely to be worse off in terms of overall living conditions, in comparison with one year previously. Households that dispose their waste in dug outs, use it as fertilizer or burn it are found to have higher perceived food situation in comparison to the previous year, all at 1% level of significance.

Table 5.1: Initial results, changes in households' food situation

Variable	Coefficient	p-value
Household-level variables		
Family size	-0.004	0.087
Own land (1=yes, 0=no)	0.129	0.000
Faced rain shortage (1=yes, 0=no)	-0.311	0.000
Water source, wet season (reference: unprotected River, lake, or pond)		
Tap in House	0.044	0.729
Tap in compound, private	0.143	0.210
Tap in compound, shared	-0.003	0.917
Tap outside compound	0.018	0.667
Protected well/spring	-0.035	0.448
Unprotected well/spring	-0.060	0.035
Rain water	0.095	0.074
Water source, dry season (reference: Tap in house)		
Tap in compound, private	-0.128	0.402
Tap in compound, shared	0.013	0.932
Tap outside compound	-0.109	0.403
Protected well/spring	-0.151	0.256
Unprotected well/spring	-0.159	0.221
River, lake or pond	-0.273	0.036
Toilet facility (reference: other)		
Flush toilet, private	0.143	0.211
Flush toilet, shared	0.124	0.115
Pit latrine, private	0.108	0.110
Pit latrine, shared	0.116	0.239
Container	0.020	0.899
Field/forest	0.042	0.700
Waste disposal (reference: other)		
Disposal vehicle	-0.075	0.143
Container	-0.0001	0.999
Dug outs	0.098	0.040
Throw away	-0.022	0.630
Use as fertilizer	0.033	0.479
Burn	0.057	0.242
cut1 | -1.356033 .1745016 (Ancillary parameters) cut2 | -.3985531 .1742652 Number of obs = 35507 Wald chi2(28) = 597.74 Prob > chi2 = 0.0000	cut3 | .5935802 .1742421 cut4 | 2.04056 .1747863 Log pseudo-likelihood = -48183.342 Pseudo R2 = 0.0069	

Source: Authors' calculations from 2004–05 Welfare Monitoring Survey.

Table 5.2: Initial results, changes in households' overall welfare situation

Variable	Coefficient	p-value
Household-level variables		
Family size	-0.004	0.100
Own land (1=yes, 0=no)	0.146	0.000
Faced rain shortage (1=yes, 0=no)	-0.336	0.000
Water source, wet season (reference: unprotected River, lake, or pond)		
Tap in House	0.062	0.637
Tap in compound, private	0.087	0.481
Tap in compound, shared	0.063	0.531
Tap outside compound	-0.020	0.634
Protected well/spring	0.0374	0.426
Unprotected well/spring	-0.033	0.239
Water source, dry season (reference: Tap in house)		
Tap in compound, private	-0.053	0.739
Tap in compound, shared	-.0109	0.943
Tap outside compound	-0.068	0.609
Protected well/spring	-0.800	0.187
Unprotected well/spring	-0.156	0.239
River, lake or pond	-0.233	0.080
Toilet facility (reference: other)		
Flush toilet, private	0.123	0.311
Flush toilet, shared	0.066	0.589
Pit latrine, private	0.074	0.529
Pit latrine, shared	0.067	0.569
Container	-0.016	0.925
Field/forest	-0.031	0.789
Waste disposal (reference: other)		
Disposal vehicle	-0.033	0.521
Container	-0.065	0.192
Dug outs	0.201	0.000
Throw away	0.072	0.134
Use as fertilizer	0.148	0.003
Burn	0.163	0.002
cut1 | -1.293504 .1809901 (Ancillary parameters) cut2 | -.3600145 .1807616 cut3 | .5884769 .1807408 cut4 | 2.090226 .1812249 Number of obs = 35507 Wald chi2(28) = 677.76 Prob > chi2 = 0.0000 Log pseudo-likelihood = -48364.41 Pseudo R2 = 0.0077		

Source: Authors' calculations from 2004–05 Welfare Monitoring Survey.

5.2 Results from household-level fixed effects approach

We now present the results of the household-level fixed effects approach, as described in Section 3.1. As previously stated in said section, we focus on the 2004 survey and run two sets of regressions. In the first, the dependent variable is the change in a household's (self-assessed) food situation, and in the second it is the change in a household's overall welfare situation. We estimate the regressions using the method of ordered probit analysis, and include three main sets of control variables. Our hypothesis is that improvements in sources of water and sanitation will be correlated with improvements in household food and overall welfare situations. We also expect that deteriorations in sources of water or sanitation will be correlated with deteriorations in household food and overall welfare situations.

The results are shown in Table 5.3. Columns 1-2 show the results when including the control variables only. 9 of the 10 variables have a negative effect on the change in households' food and overall welfare situation, which is as expected: four of these are statistically significant at the 1% level in each case. The one surprising finding is the coefficient associated with a price shock, which is positive and statistically significant at the 5% level or less. The dummy variables for each livelihood category and district (wereda) are both jointly statistically significant at the 1% level, indicating that livelihood-specific and district-specific factors had at least some effect on changes in households' food and overall welfare situations over this period.

Columns 3–4 show the results when including the water and sanitation variables. Considering first household food situations (column 3), the results indicate that improvements in drinking water source are positively correlated with improvements in food situations, and the effect is statistically significant at the 1% level. However, the correlations with deteriorations in drinking water, and with both improvements and deteriorations in sources of sanitation, are not statistically significant.

Considering the results for households' overall welfare situations (column 4), improvements in drinking water and sanitation sources are both positively correlated with improvements in overall welfare situations, as expected. However, although the former effect is statistically significant at the 5% level, neither effect is statistically significant at the 1% level. The more surprising result is that deteriorations in drinking water sources are positively associated with improvements in overall welfare status; this effect is statistically significant at the 5% level, although not at the 1% level.

Columns 5 and 6 then repeat the results, this time including dummy variables indicating whether a household has experienced an improvement or deterioration in its source of drinking water in the dry season.[9] The results are very similar. Once again, an improvement in the source of drinking water has a positive and statistically significant effect (at the 1% level) on the probability that households report an improvement in their food situation. However, neither a deterioration in the source of drinking water, nor an improvement or a deterioration in the

[9] We do not include the variables for wet and dry season water sources in the same regression, since the two variables overlap very closely.

source of sanitation, has a statistically significant effect on this probability. Moreover, none of the four water and sanitation variables has a statistically significant effect (at the 1% level) on the probability that households report an improvement in their overall welfare situation.[10]

Table 5.3: Regression results, household level fixed-effects approach

Welfare variable **Water variable**	**1** **Food** **-**	**2** **Overall** **-**	**3** **Food** **Rainy**	**4** **Overall** **Rainy**	**5** **Food** **Dry**	**6** **Overall** **Dry**
Improvement, water	-	-	0.213** 0.00	0.140* 0.02	0.229** 0.00	0.133* 0.03
Deterioration, water	-	-	0.103 0.24	0.196* 0.03	0.091 0.36	0.187 0.07
Improvement, sanitation	-	-	0.036 0.37	0.069 0.07	0.032 0.42	0.067 0.08
Deterioration, sanitation	-	-	0.055 0.48	-0.034 0.66	0.054 0.48	-0.033 0.66
Shock variables						
Death	-0.102** 0.00	-0.111** 0.00	-0.102** 0.00	-0.112** 0.00	-0.102** 0.00	-0.111** 0.00
Illness	-0.112** 0.00	-0.100** 0.00	-0.113** 0.00	-0.101** 0.00	-0.113** 0.00	-0.100** 0.00
Loss of job	-0.153* 0.03	-0.151* 0.03	-0.156* 0.03	-0.154* 0.03	-0.157** 0.00	-0.154* 0.03
Food shortage	-0.342** 0.00	-0.409** 0.00	-0.341** 0.00	-0.408** 0.00	-0.342** 0.00	-0.408** 0.00
Drought	-0.015 0.67	-0.023 0.51	-0.015 0.68	-0.023 0.51	-0.015 0.67	-0.023 0.51
Flood	-0.022 0.71	-0.013 0.82	-0.023 0.69	-0.013 0.81	-0.022 0.70	-0.013 0.81
Crop damage	-0.217** 0.00	-0.214** 0.00	-0.218** 0.00	-0.214** 0.00	-0.217** 0.00	-0.214** 0.00
Loss of livestock	-0.027 0.42	-0.020 0.54	-0.025 0.44	-0.020 0.55	-0.026 0.44	-0.020 0.55
Price shock	0.144* 0.02	0.188** 0.00	0.144* 0.02	0.188** 0.00	0.144* 0.02	0.188** 0.00
Other shock	-0.119 0.15	-0.297** 0.00	-0.120 0.15	-0.297** 0.00	-0.121 0.15	-0.297** 0.00
F-test, livelihood effects#	0.00	0.00	0.00	0.00	0.00	0.00
F-test, district effects#	0.00	0.00	0.00	0.00	0.00	0.00
Psuedo R2	0.067	0.069	0.068	0.070	0.068	0.070
N	34,738	34,738	34,738	34,738	34,738	34,738

Notes: p-values are shown beneath each coefficient; * indicates coefficient is statistically significant at the 5% level; ** indicates coefficient is statistically significant at the 1% level; # shows the p-value associated with a test of the null hypothesis that all livelihood or district effects are zero. Regressions are estimated using survey weights.

Source: Authors' estimations from WMS 2004 survey.

[10] If we were to use a 5% significance level, the only difference would be that the effect of improvements in water source would be statistically significant, and positive as expected. As argued above, a 10% significance level would not be appropriate in this case, given the sample size.

We have tried estimating the above regressions separately by region (results available on request). In this case, the estimated coefficients on the water and sanitation improvement and deterioration variables are mostly statistically insignificant (at either the 1% or 5% level). Most probably, this reflects the small number of surveyed households in each region (as opposed to the national level) which witnessed a change in their source of water or sanitation, which raises the margin for error in statistical comparisons. The exceptions are Amhara and Addis Ababa, where improvements in water source have a positive and statistically significant effect (at the 1% and 5% levels respectively) on the probability that households report an improvement in their food situation, and Oromia, where, contrary to expectation, deteriorations in water source have a positive and statistically significant effect (at the 5% level).[11]

Overall therefore, the results provide some limited support for the research hypotheses. On one hand, we do find that improvements in household drinking water sources are positively correlated with (self-assessed) improvements in households' food situations, at a high level of statistical significance. On the other hand, we do not find similar (negative) correlations in the case of deteriorations in household drinking water sources, nor do we find statistically significant correlations in the case of improvements or deteriorations in household sanitation sources. In addition, we do not find any correlations which are significant at a high level when considering (self-assessed) changes in households' overall welfare status.

5.3 Zone level results

In this section we present our estimates of the effect of distance to nearest source of drinking water on school enrolment and employment. We use four different dependent variables in the analysis, each measured at the zone level. These are:

- proportion of boys (ages 10-14) registered to attend school
- proportion of girls (ages 10-14) registered to attend school.
- proportion of men (ages 25-54) in productive employment
- proportion of women (ages 25-54) in productive employment

These variables are calculated by averaging the individual-level information on employment, health and school enrolment contained in the 2000 and 2004 surveys across each zone.[12] Descriptive statistics for these variables are shown in the upper panel of Table 17. Thus in 2000 the average proportion of boys registered to attend school (measured across 53 zones) was 0.439, while in 2004 the average proportion (measured across 61 zones) was 0.519, and so on.

For explanatory variables, we include the average distance of households in each zone from eleven different types of facilities, namely: food market, post office, primary school, secondary school, bus or taxi service, all weather road, dry weather road, drinking water in dry season,

[11] These are when considering the food welfare measure, and source of water in the rainy season.

[12] These averages are calculated using survey weights.

drinking water in wet season, telephone booth, and milling house. These variables are calculated by averaging the (self-reported) household-level information on distance from each type of facility contained in the 2000 and 2004 surveys across each zone.[13] Descriptive statistics for these variables are shown in the lower panel of Table 5.4. Thus in 2000 the mean average distance of households from nearest food market was 7.8km (measured across 53 zones), and 7.9km (averaged across 61 zones) in 2004.

Table 5.4: Zone-level descriptive statistics

	2000				2004			
	Mean	S.d	Min	Max	Mean	S.d	Min	Max
Dependent variables (proportions)								
Enrolment, boys	0.439	0.195	0.018	0.942	0.519	0.160	0.111	0.806
Enrolment, girls	0.323	0.147	0.009	0.739	0.425	0.163	0.064	0.805
Employment, men	0.973	0.015	0.942	0.996	0.936	0.030	0.844	0.986
Employment, women	0.608	0.190	0.137	0.936	0.580	0.157	0.258	0.878
Distance measures (km)								
Food market	7.8	4.9	2.8	37.4	7.9	3.4	2.5	17.8
Post office	25.0	11.5	8.1	62.7	24.8	12.9	6.8	66.5
Primary school	4.2	2.6	2.0	20.6	4.1	1.7	1.0	8.5
Secondary school	24.1	10.8	6.6	64.3	21.7	10.5	3.6	52.4
Bus or taxi service	22.0	14.2	4.7	72.8	20.5	13.9	4.0	66.7
All weather road	12.5	7.4	2.5	37.3	12.1	7.7	2.1	41.2
Dry weather road	8.8	5.2	1.7	21.2	8.5	4.6	1.6	24.9
Drinking water, dry	1.0	0.4	0.6	2.3	2.0	1.1	0.8	6.3
Drinking water, rainy	1.5	1.0	0.6	6.6	1.6	0.8	0.7	6.1
Telephone booth	26.6	14.5	5.7	73.8	19.6	9.0	4.1	46.8
Milling house	6.2	4.9	1.8	34.7	5.5	3.0	1.5	15.0

Notes: The number of zones is 53 in 2000 and 61 in 2004.

Source: Authors' calculations from 2000 and 2004 WMS surveys.

We now discuss the (bivariate) correlations between the variables used in the analysis, which are shown in Table 5.5. There are three main points to note from this table. The first is that there is a negative bivariate correlation between all four dependent variables and average

13 The averages are again calculated using survey weights. There are, however, two differences between the two surveys in the way this information is reported. First, in the 2000 survey any distance less than 1km is given a figure of zero, whereas in the 2004 survey distances less than 1km are reported to one decimal place (0.1km. 0.2km etc.). Second, in the 2000 survey the distance data are truncated at 100km, whereas in the 2004 survey they extend beyond 100km. To prevent these differences from obscuring comparisons between the two surveys, we recode any reported distance of 90km or above as 100km, and any distance less than 1km as 0.5km.

distance from drinking water in both the wet and the dry season. This correlation is also statistically significant, in six out of eight cases at the 1% level and five out of eight cases at the 5% level.

The second point is that there is a positive and statistically significant correlation between most of the distance measures. This suggests that the bivariate correlations between the dependent variables and distance to drinking water may be somewhat misleading. It also suggests a potential difficulty in separating out the effect of distance from each type of facility on the dependent variables (the problem of multicollinearity).

The third point is that there is a particularly high correlation between average distance from drinking water in the rainy season and distance from drinking water in the dry season (0.75). For this reason we run two separate regressions for each dependent variable: one includes distance from water in the dry season and the other includes distance from water in the rainy season.

We now turn to the regression results, which are shown in Table 5.6. Four sets of results are shown, corresponding to four different specifications of the regression. In the first two specifications (panels A and B), the dependent variable is measured as a proportion, whereas in the second two specifications (panels C and D) it is measured as a log odds-ratio. In each case, in one specification distance is measured in kilometres (panels A and C), whereas in the other it is measured in log units (panels B and D). To prevent over-complication, only the coefficients on the distance to water variables are shown, together with the results of some basic diagnostic tests. The results for all other explanatory variables included in each regression are available in the appendix.

On the whole, the zonal-level regression results do not support the research hypotheses. Although the majority of estimated coefficients on the distance to water variables are negative, as expected, few are statistically significant. Most importantly, none are statistically significant (at the 1%, 5% or 10% level) when using the preferred first-differencing approach. Those distance variables which are found to have a negative and statistically significant effect are distance from primary school (for girls' and boys' school enrolment, and male employment), distance from food market (for female employment) and distance from all weather roads (for male employment).

The results in Table 5.6 do not necessarily imply that distance from sources of drinking water has no effect on enrolment or employment. Instead, there are various reasons why the approach used in this section may fail to pick up these effects, including: a) limited measures of enrolment and employment (both being discrete, 0-1 variables); and b) a relatively small number of units (i.e. zones) included in the analysis. There is little that can be done about the first of these problems, since no other measures of enrolment or employment are available in the WMS surveys.

There is potentially a way of addressing the second problem, however, which is to repeat the analysis, using data at the district (wereda) level. As discussed in Section 3.2.2, this would raise the sample size in the regressions from around 50 to 400 observations. Although the district-level data would be subject to higher measurement error (being based on fewer sample observations), this can be offset using the approach suggested by Deaton (1985).

Initial analysis of district-level data is shown in Table 5.7. This shows the results of equivalent regressions in levels to those shown in Table 5.6, but in this case using district rather than zone-level data. These results must be treated with caution, since the basic diagnostic tests are frequently not met, and we are unable in this case to compare the results of regressions in levels as opposed to first-differences. Nevertheless, the results do show at least some support for the research hypotheses. In particular, there is a negative and statistically significant relationship between distance to water and female employment in the third specification (panel C), between distance to water in the dry season and male employment in the fourth specification (panel D), and distance to water in the rainy season and boys' school enrolment in the second specification (panel B). (In each of these cases, basic diagnostic tests are satisfied). It would be interesting to see whether this result continues to apply when using the fixed-effects approach.

Table 5.5: Bivariate correlations

	Enrolment, boys	Enrolment, girls	Employment, men	Employment, women	Food market	Post office	Primary school	Secondary school	Bus or taxi service	All weather road	Dry weather road	Drinking water, dry	Drinking water, rainy	Telephone booth	Milling house
Enrolment : boys	1.000														
Enrolment: girls	0.632**	1.000													
	0.00														
Employment: men	-0.069	0.043	1.000												
	0.47	0.65													
Employment: women	0.163	0.059	0.241*	1.000											
	0.08	0.53	0.01												
Food market	-0.436**	-0.162	-0.073	-0.134	1.000										
	0.00	0.08	0.44	0.15											
Post office	-0.302**	-0.361**	0.011	0.271**	0.449**	1.000									
	0.00	0.00	0.91	0.00	0.00										
Primary school	-0.494**	-0.310**	-0.011	-0.011	0.772**	0.634**	1.000								
	0.00	0.00	0.91	0.91	0.00	0.00									
Secondary school	-0.386**	-0.334**	0.144	0.161	0.606**	0.763**	0.734**	1.000							
	0.00	0.00	0.13	0.09	0.00	0.00	0.00								
Bus or taxi service	-0.206*	-0.313**	0.022	0.301**	0.289**	0.831**	0.472**	0.736**	1.000						
	0.03	0.00	0.82	0.00	0.00	0.00	0.00	0.00							

	Enrolment, boys	Enrolment, girls	Employment, men	Employment, women	Food market	Post office	Primary school	Secondary school	Bus or taxi service	All weather road	Dry weather road	Drinking water, dry	Drinking water, rainy	Telephone booth	Milling house
All weather road	-0.270**	-0.176	0.161	0.158	0.386**	0.758**	0.595**	0.772**	0.773**	1.000					
	0.00	0.06	0.09	0.09	0.00	0.00	0.00	0.00	0.00						
Dry weather road	-0.170	-0.023	0.208*	0.137	0.330**	0.575**	0.484**	0.608**	0.581**	0.808**	1.000				
	0.07	0.81	0.03	0.15	0.00	0.00	0.00	0.00	0.00	0.00					
Drinking water: dry season	-0.182*	-0.036	-0.436**	-0.168	0.324**	0.071	0.263**	0.074	-0.085	-0.077	-0.042	1.000			
	0.05	0.70	0.00	0.07	0.00	0.45	0.00	0.43	0.37	0.42	0.66				
Drinking water: rainy season	-0.366**	-0.193*	-0.198*	-0.115	0.434**	0.146	0.376**	0.215*	-0.006	-0.054	-0.072	0.745**	1.000		
	0.00	0.04	0.03	0.22	0.00	0.12	0.00	0.02	0.95	0.57	0.44	0.00			
Telephone booth	-0.285**	-0.323**	0.200*	0.264**	0.458**	0.839**	0.618**	0.838**	0.756**	0.765**	0.576**	-0.079	0.112	1.000	
	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.23		
Milling house	-0.324**	-0.262**	-0.025	0.025	0.519**	0.493**	0.624**	0.523**	0.455**	0.409**	0.290**	0.060	0.206*	0.487**	1.000
	0.00	0.00	0.79	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.03	0.00	

Notes: * indicates coefficient is statistically significant at the 5% level; ** indicates coefficient is statistically significant at the 1% level. Distance is measured in log kilometres, and results are pooled across the 2000 and 2004 surveys (n=114).

Source: Authors' calculations from WMS 2000 and 2004 data.

Table 5.6: Regression results (summary): effects of distance from source of drinking water, zone-level

	School enrolment, boys		School enrolment, girls		Employment, men		Employment, women	
	Levels	First differences	Levels	First differences	Levels	First differences	Levels	First differences
A: dependent variable=proportion; distance in km								
Coefficient (dry season)	-0.008 0.65	0.002 0.87	-0.005 0.75	0.001 0.94	-0.012** 0.00	0.000 0.96	-0.022 0.23	-0.016 0.53
Coefficient (rainy season)	-0.035 0.11	0.012 0.44	-0.025 0.23	-0.012 0.51	-0.004 0.32	-0.003 0.52	-0.005 0.81	-0.010 0.74
Diagnostic tests met?#	Yes	Yes	No	Yes	No	No	Yes	Yes
B: dependent variable=proportion; distance in log km								
Coefficient (dry season)	-0.010 0.78	0.021 0.51	0.011 0.74	-0.004 0.92	-0.025** 0.00	0.006 0.60	-0.029 0.42	-0.035 0.57
Coefficient (rainy season)	-0.084* 0.04	0.019 0.57	-0.025 0.51	0.001 0.98	-0.010 0.16	0.006 0.60	-0.024 0.56	-0.026 0.69
Diagnostic tests met?#	No	Yes	No	Yes	No	No	Yes	Yes
C: dependent variable=log-odds ratio; distance in km								
Coefficient (dry season)	-0.017 0.83	-0.005 0.94	-0.008 0.92	0.087 0.29	-0.294** 0.00	-0.034 0.77	-0.098 0.25	-0.048 0.71
Coefficient (rainy season)	-0.219* 0.03	0.046 0.54	-0.171 0.11	-0.091 0.33	-0.056 0.59	-0.023 0.86	-0.042 0.69	-0.075 0.61
Diagnostic tests met?#	No	No	No	No	No	No	Yes	Yes
D: dependent variable=log-odds ratio; distance in log km								
Coefficient (dry season)	-0.052 0.77	0.069 0.65	0.053 0.75	0.081 0.68	-0.610** 0.00	0.199 0.48	-0.151 0.37	-0.094 0.76
Coefficient (rainy season)	-0.543** 0.01	0.024 0.88	-0.217 0.26	-0.108 0.60	-0.216 0.26	0.269 0.37	-0.166 0.39	-0.201 0.54
Diagnostic tests met?#	No	Yes	No	Yes	No	No	No	Yes

Notes: * indicates coefficient is statistically significant at the 5% level; ** indicates coefficient is statistically significant at the 1% level; # include tests for heteroscedasticity, functional form, influential observations, and normality of residuals. All regressions include distance from nine other types of facilities as control variables (see Appendix). Number of observations is 114 for the levels regressions and 51 for the first-differenced regressions. *Source*: Authors' calculations from WMS 2000 and 2004 surveys.

Table 5.7: Regression results (summary): effects of distance from source of drinking water, district-level

	School enrolment, boys	School enrolment, girls	Employment, men	Employment, women
A: dependent variable=proportion; distance in km				
Coefficient (dry season)	0.001	-0.006	-0.002*	-0.015*
	0.77	0.26	0.05	0.01
Coefficient (rainy season)	-0.013*	-0.013*	-0.001	-0.020**
	0.02	0.03	0.34	0.01
Diagnostic tests met?#	No	No	No	No
B: dependent variable=proportion; distance in log km				
Coefficient (dry season)	0.008	0.025	-0.016**	-0.020
	0.57	0.08	0.00	0.19
Coefficient (rainy season)	-0.030*	-0.007	-0.011**	-0.025
	0.04	0.67	0.00	0.12
Diagnostic tests met?#	Yes	No	No	No
C: dependent variable=log-odds ratio; distance in km				
Coefficient (dry season)	0.009	-0.017	-0.034	-0.070*
	0.68	0.51	0.15	0.02
Coefficient (rainy season)	-0.037	-0.057	-0.003	-0.103**
	0.13	0.09	0.93	0.01
Diagnostic tests met?#	No	No	No	Yes
D: dependent variable=log-odds ratio; distance in log km				
Coefficient (dry season)	0.051	0.088	-0.134*	-0.086
	0.39	0.18	0.03	0.25
Coefficient (rainy season)	-0.069	-0.019	-0.043	-0.119
	0.27	0.79	0.52	0.14
Diagnostic tests met?#	No	Yes	Yes	Yes

Notes: * indicates coefficient is statistically significant at the 5% level; ** indicates coefficient is statistically significant at the 1% level; # include tests for heteroscedasticity, functional form, influential observations, and normality of residuals. All regressions include distance from nine other types of facilities as control variables. Number of observations is 874; results are shown for regressions in levels only (first differencing not possible).
Source: Authors' calculations from WMS 2000 and 2004 surveys.

6 Conclusions

The main findings of the paper can be summarised as follows.

First, in the 2004–05 survey, there is a positive and statistically significant relationship between improvements in households' sources of drinking water, and improvements in households' (self-reported) food situations. In other words, households experiencing an improvement in their source of drinking water were more likely to report an improvement in their food situation, and less likely to report deterioration. This is controlling for a variety of other influences on the likelihood that a household reports an improvement or deterioration in its food situation, including adverse household shocks, the type of household livelihood, and district (wereda) level variations.

One explanation for this finding is that an improvement in the quality of water reduces illness among children and adults, which in turn tends to raise productive employment (as discussed in Section 2). This would in turn tend to improve a household's food situation. We cannot be entirely sure that this explanation is the correct one however, mainly because there is the possibility that improvements in sources of drinking water are being driven by some other unobserved factor, which also happens to be improving households' food situations.

Second, in the same survey, we do not find a statistically significant relationship between improvements in households' sources of drinking water, and changes in their (self-reported) overall welfare situations. In other words, households experiencing an improvement in their source of drinking water were no more likely to report an improvement (or deterioration) in their overall welfare situation, in comparison with other households. This is despite the fact that they were more likely to report an improvement in their food situation. One possible explanation for this finding is that a household's overall welfare situation is affected by a much wider range of factors, which obscures the contribution of improvements in sources of drinking water.

Third, we also do not find any statistically significant relationships between changes in households' sources of sanitation, and changes in households' (self-reported) food or overall welfare situations. In other words, households experiencing an improvement (or deterioration) in their source of sanitation were no more likely to report an improvement (or deterioration) in their food situation, or their overall welfare situation, in comparison with other households.

Fourth, when carrying out the analysis at the zonal-level, although the effect of distance to drinking water on productive employment and school enrolment is found to be negative, the results are not statistically significant (at the 1%, 5% or 10% level). Those distance variables which are found to have a negative and statistically significant effect are distance from primary school (for girls' and boys' school enrolment), distance from food market (for female productive employment) and distance from all weather roads (for male productive employment).

Finally, although initial analysis of district (wereda) level data shows a negative and statistically significant relationship between distance to water and female employment, we are unable in this case to use our preferred estimation method (that of regressions in first-differences as opposed to levels), and for this reason this result must be treated with caution (it may reflect spurious correlation).

To summarise, our analysis provides only some limited evidence of significant economic benefits to improvements in access to drinking water and sanitation. It is worth stressing that this is as likely to be the result of certain inadequacies in the survey data used in the analysis as a reflection of an actual lack of economic benefits. The most serious problems are: a) households (or districts) cannot be tracked over time; b) data on income are not available in both surveys; and c) data on the time allocated by household members to different activities (e.g. water collection, productive employment, education) are not available in both surveys.

In terms of implications and next steps, one option would be to repeat the analysis carried out in Section 5.3 at the district (wereda) level. This would require matching up districts in the two surveys, which in turn requires the list of wereda codes contained in the survey datasets released by the Ethiopian Central Statistics Agency. Another option would be to look at alternative sources of survey data for Ethiopia, such as the Demographic Health Surveys (available for 2000 and 2005). These are not panel datasets either, but it may again be possible to link districts between the two surveys and carry out district-level fixed-effects regressions.

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Annex I: Test results disaggregated into urban and rural

Access to Water source dry season disaggregated into Urban and Rural (proportion)

Water source	Urban (n= 8632)	Rural (n= 17259)
Tap in household	0.02	0.00
Compound private Tap	0.22	0.00
Compound shared Tap	0.15	0.00
Out of compound	0.47	0.06
Protected well/spring	0.07	0.13
Unprotected well/spring	0.03	0.40

Source: Authors' calculations from the 1999–2000 Welfare Monitoring Surveys.
Test results of equality in 2000: Pearson chi2 (49) = 185.8993 Pr = 0.000

Access to Water source wet season disaggregated into Urban and Rural (proportion)

Water source	Urban (n= 8633)	Rural (n= 17261)
Tap in household	0.02	0.00
Compound private Tap	0.22	0.00
Compound shared Tap	0.46	0.05
Out of compound	0.46	0.05
Protected well/spring	0.07	0.12
Unprotected well/spring	0.03	0.38
Rain	0.03	0.02

Source: Authors' calculations from the 1999–2000 Welfare Monitoring Surveys.
Test results of equality in 2000: Pearson chi2 (49) = 185.8993 Pr = 0.000

Access to toilet facilities disaggregated into Urban and Rural (proportion)

Toilet facilities	Urban (n= 8640)	Rural (n=17260)
Flush Toilet, private	0.04	0.01
Flush toilet, shared	0.04	0.00
Pit latrine, private	0.35	0.08
Pit latrine, shared	0.34	0.03
Bucket	0.01	0.00
Field/Forest	0.22	0.89
Other	0.01	0.00

Source: Authors' calculations from the 1999–2000 Welfare Monitoring Surveys.
Test results of equality in 2000: Pearson chi2 (49) = 185.8993 Pr = 0.000

Access to dry waste disposal disaggregated into Urban and Rural (proportion)

Waste disposal	**Urban (n= 8640)**	**Rural (n=17260)**
Vehicle/container	0.22	0.00
Dug out	0.14	0.02
Throw away	0.04	0.57
Use as fertilizer	0.04	0.39
Burning	0.17	0.02
Other	0.04	0.00

Source: Authors' calculations from the 1999–2000 Welfare Monitoring Surveys.

Test results of equality in 2000: Pearson chi2 (49) = 185.8993 Pr = 0.000

Working
Paper 3