**Institute for Economic Studies, Keio University**

**Keio-IES Discussion Paper Series**

# The Impact of Improved Access to Safe Water on Childhood Health, Schooling and Time Allocation in Rural Zambia

**島村靖治、清水谷諭、田口晋平、山田浩之**

**2020 年 11 月 25 日**
**DP2020-022**
**https://ies.keio.ac.jp/publications/13592/**

Institute for Economic Studies, Keio University
2-15-45 Mita, Minato-ku, Tokyo 108-8345, Japan
ies-office@adst.keio.ac.jp
25 November, 2020

The Impact of Improved Access to Safe Water on Childhood Health, Schooling and Time Allocation in Rural Zambia

島村靖治、清水谷諭、田口晋平、山田浩之

IES Keio DP2020-022
2020 年 11 月 25 日
JEL Classification: I38, J22, J16
キーワード: fetching water; borehole; waterborne diseases; Zambia; time use

## 【要旨】

This paper examines the short term impact of improved access to supremely safe water at newly built boreholes on the health, schooling and time allocation of children in rural Zambia. We employ a difference-in-difference estimation using a dataset collected under a quasi-experimental setting. We observe positive and significant effects of improved access to safe water on the reduction of incidence of diarrhea for pre-school children but not for school age children. On the other hand, we do not find any positive effect on school attendance and even suggest that there is a negative effect on girls living surrounding new boreholes. To understand the mechanism behind this pattern, we examine any changes in the use of time by children with easier access to safe water. We find for girls a significant increase in time spent on water-related household chores including fetching water. Moreover, we observe a significant decrease in the income-generating activities of girls. These findings, together with the suggestive evidence of increased demand for supremely safe water available at boreholes with easier access, imply that the burden of water-related household chores appears to shift from mothers to daughters.

島村靖治
神戸大学大学院国際協力研究科
〒657-8501
兵庫県神戸市灘区六甲台町2-1
yshima@harbor.kobe-u.ac.jp

清水谷諭
国際協力機構　緒方貞子平和開発研究所
〒162-8433
東京都新宿区市谷本村町10-5
Shimizutani.Satoshi@jica.go.jp

田口晋平
国際協力機構　緒方貞子平和開発研究所　企画課
〒162-8433
東京都新宿区市谷本村町10-5
Taguchi.Shimpei@jica.go.jp

山田浩之
慶應義塾大学　経済学部
〒108-8345
東京都港区三田2-15-45
hyamada@econ.keio.ac.jp

謝辞: This study was conducted as part of the project "Empirical Research in Africa" at the JICA Ogata Sadako Research Institute for Peace and Development, which sponsored our data collection and gave us formal permission to use these data. We thank the Ministry of Local Government and Housing of Zambia and the Japan International Cooperation Agency for permission to conduct the study. We also thank Nobuhide Hayashi, Ryuji Ogata, Etsuko Masuko and Eiji Yamada for their constructive comments on the draft. The views expressed in the paper are those of the authors and do not represent the official positions of either the JICA Ogata Sadako Research Institute for Peace and Development or JICA. The authors are responsible for any errors or omissions.

# The Impact of Improved Access to Safe Water on Childhood Health, Schooling and Time Allocation in Rural Zambia

by

**Yasuharu Shimamura*, Satoshi Shimizutani**, Shimpei Taguchi*** and Hiroyuki Yamada******

## Abstract

This paper examines the short term impact of improved access to supremely safe water at newly built boreholes on the health, schooling and time allocation of children in rural Zambia. We employ a difference-in-difference estimation using a dataset collected under a quasi-experimental setting. We observe positive and significant effects of improved access to safe water on the reduction of incidence of diarrhea for pre-school children but not for school age children. On the other hand, we do not find any positive effect on school attendance and even suggest that there is a negative effect on girls living surrounding new boreholes. To understand the mechanism behind this pattern, we examine any changes in the use of time by children with easier access to safe water. We find for girls a significant increase in time spent on water-related household chores including fetching water. Moreover, we observe a significant decrease in the income-generating activities of girls. These findings, together with the suggestive evidence of increased demand for supremely safe water available at boreholes with easier access, imply that the burden of water-related household chores appears to shift from mothers to daughters.

Keywords: fetching water; borehole, waterborne diseases, groundwater development, Zambia, schooling, time use.

JEL Classification Codes: I38, J22, J16.

---

* Professor, Graduate School of International Cooperation Studies, Kobe University; 2-1 Rokkodai-cho, Nada-ku, Kobe 657-8501, Japan, Tel: +81-78-803-7158, Email: yshima@harbor.kobe-u.ac.jp.
** (Corresponding author) Executive Senior Research Fellow, JICA Ogata Sadako Research Institute for Peace and Development; 10-5 Ichigaya Honmuracho, Shinjuku-ku, Tokyo 162-8433, Japan, Tel: +81-(0)3-3269-2911, FAX: +81-(0)3-3269-2054 E-mail: Shimizutani.Satoshi@jica.go.jp.
*** Planning devision, JICA Ogata Sadako Research Institute for Peace and Development; 10-5 Ichigaya Honmuracho, Shinjuku-ku, Tokyo 162-8433, Japan, Tel: +81(0)3 3269 2357 Email: Taguchi.Shimpei@jica.go.jp.
**** Professor, Faculty of Economics, Keio University; 2-15-45 Mita, Minato-ku, Tokyo 108-8345 Japan, Tel (Direct): +81-(0)3-5427-1271 E-mail: hyamada@econ.keio.ac.jp.

**Acknowledgements**

This study was conducted as part of the project "Empirical Research in Africa" at the JICA Ogata Sadako Research Institute for Peace and Development, which sponsored our data collection and gave us formal permission to use these data. We thank the Ministry of Local Government and Housing of Zambia and the Japan International Cooperation Agency for permission to conduct the study. We also thank Nobuhide Hayashi, Ryuji Ogata, Etsuko Masuko and Eiji Yamada for their constructive comments on the draft. The views expressed in the paper are those of the authors and do not represent the official positions of either the JICA Ogata Sadako Research Institute for Peace and Development or JICA. The authors are responsible for any errors or omissions.

## 1. Introduction

This paper examines the short-run impacts on children of improved access to supremely safe water sources made available at newly built boreholes constructed by a groundwater development project in terms of the incidence of waterborne diseases, schooling and the use of time in rural Zambia.

Access to safe water is a basic need for all people and forms an essential part of improving their well-being. The United Nation (UN)'s Sustainable Development Goals (SDGs) aims to "[E]nsure access to water and sanitation for all" by 2030 (Goal 6), and calls for ensuring universal and equitable access to safe and affordable drinking water for all by 2030 (Goal 6.1) (United Nations n.d.). For years, many efforts have been devoted to make safe drinking water accessible for all human beings but the reality in 2020 is far below the goal and is particularly unsatisfactory in rural areas. In 2017, 579 million people globally did not have access to water from improved sources, while 80 percent of those people without even basic drinking water services lived in rural areas (UNICEF and WHO 2019).[1]

The critical importance of access to safe water sources has been reinforced in the hygiene area by the outbreak of the COVID-19 pandemic in 2020, since hand-washing is considered as an effective way to prevent infections such as the COVID-19 virus.

[1] There are five "ladders" of water service level. "Safely managed" points to drinking water from an improved water source that is located on the premises, available when needed and free from faecal and chemical contamination. "Basic," which is defined as a part of SDG Goal 1.4, is drinking water from an improved water source, provided collection time is not more than 30 minutes for a round trip including queuing. "Limited" refers to drinking water from an improved source for which collection time exceeds 30 minutes for a round trip including queuing. "Unimproved" is drinking water from unprotected dug well or unprotected spring. "Surface water" is drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal (UNICEF and WHO 2017). The "Improved" water sources of the first three levels (safely managed, basic and limited) include piped water, boreholes or tube wells, protected dug wells, protected springs, and packaged or delivered water.

However, 40 percent of people in the world did not have a basic hand-washing facility with soap and water and 3 billion people lacked basic handwashing facilities at home in 2017 (UNICEF and WHO 2019).

In addition to the large disparity between urban and rural areas, access to safe water is very unequal between developed and developing countries and is most limited in the Sub-Saharan African countries. According to UNICEF and the WHO (2019), the proportion of people in this area enjoying "safely managed drinking water service" and "basic drinking water service" (i.e., at lease basic water service) increased from 46% in 2000 to 61% in 2017, but this was still below the worldwide average of 90%. World-wide, 207 million people still used sources where water collection exceeded 30 minutes in 2017 and 135 million of them lived in Sub-Saharan countries.

In those countries, the adverse effect of lacking access to safe water is disproportionally concentrated on children. First, lack of access to safe water is a major cause of waterborne diseases which are devastating to children. Indeed, nearly 1,000 children die every day due to preventable water and sanitation-related diarrheal diseases. Second, children are often forced to carry heavy loads when collecting water; adult women and girls are responsible for fetching water in 80% of households without access to water on the premises (United Nation n.d.). Third, the high prevalence of diarrhea and the heavy burden of water collection may have negative effect on schooling outcomes. In 2018, 258 million school age children were not in school and 38% of these were concentrated in the Sub-Saharan African countries (UNESCO 2020)[2].

[2] The proportion of out-of-school students were 19% of primary school students, 37% of lower secondary students and 58% of upper secondary students in Sub-Saharan Africa in 2018. The proportion of school enrollment was lower for girls by 5 percent in all ages in the area (UIS, 2019).

This study endeavors to provide new evidence about the short-term and extensive impact of improved access to safe water from newly built boreholes on children's lives in terms of health, schooling and their use of time in rural Zambia. We build on three strands in the literature. The first strand is the large volume of evidence on the effect of improved access to safe water on health. The motivation behind this is that access to safe water is likely to contribute to a reduction in the waterborne diseases that are prevalent in developing countries. These studies have shown two stylized facts. First, improvement of water quality at point of use (POU) is generally more effective in reducing waterborne diseases than other interventions (Gundry et al. 2004; Fewtrell et al. 2005; Arnold and Colford, 2007; Waddington and Snilstveit 2009; Clasen et al. 2015). Second, whether any improvement of water sources has a positive impact on the quality of the water used or on health of the target population is inconclusive (Wright et al. 2004; Zwane and Kremer 2007; Waddington and Snilstveit 2009; Kremer et al. 2011). Those two facts imply that access to safe water improves quality of water at the point of collection (POC) but may not change it at the point of use (POU). This deterioration of water quality is attributed to recontamination by mishandling improved source water (Fewtrell et al. 2005; Günther and Schipper 2013) or the mixed use of water of unknown quality (Kremer et al. 2011).

The second line of previous related studies examines the impact of improved access to safe water on schooling outcomes. Improved access to water sources may gain time that can be used for prolonged schooling since water collection burdens fall heavily on children (WHO 2007; Morrison, Raju, and Sinha 2007; Ray 2007), and may help children to attend school by reducing waterborne diseases (see the first strand). If we expand the scope of the time saving effect on mothers, the impact is complex and less obvious. If mothers start to be engaged in market-based work free from on water collection, the income effect can make schooling and health care affordable and help children to attend schools. On the other hand, if the labor force participation of mothers outside the home deprives them of time for housework, the substitution effect may offset the income effect and adolescent girls may be more responsible for housework instead of mothers. While Koolwal and Van deWalle (2013) found a positive correlation between school enrolment and time reduction to water sources for both boys and girls in non-African countries[3], Deveto et al. (2012) found that private connection to the public water system did not have any impact on school completion, on the intensive margin of schooling, or on time spent on homework, but increased time saved was spent on leisure. Gross et al. (2018) also showed little impact of public water provision on schooling because the time saving from improved access to water sources was small and suggested that boys, not girls, are more likely to go to school in this situation.

The third strand of the relevant literature is on the time burden in fetching water. Rosen and Vincent (1999) show that women spend 2–3 hours per day on water collection on average in rural Sub-Saharan Africa. Given this large burden of water collection, improved access to safe water may reduce the distance from house to water source and thus save time spent on collecting water. If this is the case, time gains are more beneficial for those women and girls who are mainly responsible for water collection (Ray 2007; Sorenson et al. 2011; Koolwal and Van de Walle 2013).

[3] They found a positive effect on schooling in Yemen, Morroco, and Nepal but not in Uganda, Malawi, Madagascar and Rwanda. Nauges and Strand (2017) show a significantly negative relation between girls' school attendance and fetching water time and noted that the impact is stronger in rural areas in Ghana by using an artificial panel of clusters. Outside Sub-Saharan African countries, Zhang and Xu (2016) show a long-run and positive effect of water treatment programs on girls' school attainment in rural China.

However, compared to the first strand of papers on health, there is a smaller volume of empirical literature on the impact of improved access to water source on water collection time. Most studies in Sub-Saharan African countries used cross sectional data on a limited number of villages and showed that the estimated time saving by improved access to water sources ranged widely from 30 to 300 minutes (Cairncross and Cliff 1987; Bevan et al. 1989; Blum et al. 1990). Recently, two papers used longitudinal data to examine the time saving effect rigorously. Devoto et al. (2012) used an experimental design to examine the impact of private piped water connections to the water mains in Morocco's urban areas and found that 27 minutes were saved per day if households switched from a public to a private connection. Gross et al (2018) found that the provision of new public water points saved 41 minutes per day for water collection activities on average in rural Benin. Those estimates are among the lowest in previous studies partly because reduced distance to water sources motivated households to demand a larger number of water containers collected per day.[4]

This study agrees with those of Deveto et al (2012) and Gross et al (2018) that used longitudinal data to contribute to the literature on improved access to safe water by children. Since the interval of our longitudinal dataset is one year and the period of use of new boreholes averages 6 months, we capture the short run impact of these projects. We focus on the impact on children under age 18 and aim to add new insights in three ways:

First, we examine the impact of access to supremely safe water from boreholes

[4] In addition, Graham et al. (2016) measures the burden of water collection by spending more than 30 minutes and reports that adult females are primarily responsible for collecting water among households and girls were more likely to be responsible for water collection than boys (62% and 38%) in all 24 Sub-Saharan African countries in the study. However, this study did not include Zambia.

whose depth is approximately 60 meters on a variety of outcomes for children. There is no concern about the quality of water at source and therefore we exclude the possibility that our results are susceptible to potential contamination at source. Before the boreholes were handed over to villagers, it was confirmed that the quality of water passed a variety of tests including electrical conductivity, pH, iron, manganese, and fluorine content, in addition to the amount of Escherichia coli. To our knowledge, most previous studies do not provide evidence on the impact of completely uncontaminated water confirmed by a variety of quality tests. Moreover, the boreholes in the project were communal and were handed over to villagers together with the reorganization of the Village Water, Sanitation and Health Education (V-WASHE) Committee that is responsible for general and daily operations and maintenance at the village level.

Second, we employ a detailed time use survey to explore any possible change in time allocation on a variety of activities resulting from improved access to safe water. In contrast to previous studies relying on information on the incidence of engagement and time spent on specific activities, we utilize an exhaustive timetable for the whole day from 5 am to 10 pm to investigate the mechanism of the impact of access to safe water source on time allocation by children. This complete time use survey is essential to understand the comprehensive channels of the impact of improved safe water access on children.

Third, we consider distance from house to water sources using information on location of each household, a factor that has largely been ignored. Naturally, the impact of access to improved water access may be different across households at different locations and households located near water sources may demand more water than households located far from the sources. We have measures of distance from house to water sources in terms of physical distance and time that allow us to examine the burden of water collection in a more subtle way.

This paper proceeds as follows. The next section describes the target project and our research design. Section 3 illustrates the data set. Section 4 explains our empirical strategy. Section 5 gives the estimation results and discusses the findings. Section 6 concludes.

## 2. The project and research design

In this section, we explain briefly the status of water access in Zambia and the Luapula province, the site of our study. Then, we turn to describe the groundwater development project by the Japan International Cooperation Agency (JICA), which is the intervention in this study. Lastly, we explain the research design of our study.

### (1) Zambia and the Luapula province

Zambia is a landlocked sub-Saharan African country whose population was 17 million in 2019. As is the case with surrounding countries, Zambia is no exception in that expanding coverage of water supplies is one of the most important policy challenges for the community. In 2015, 67.7% of households had access to improved sources of drinking water[5] in the country (Central Statistical Office 2016), a slight improvement on 62% in 2010. However, there was a wide regional variation between urban (89.2%) and rural areas (51.6%) (Central Statistical Office 2011). Many people,

[5] An "improved" drinking water source adequately protects the source from outside contamination, particularly faecal matter, by the nature of its construction and when properly used. The sources include piped water into dwellings, piped water to yard/plots, public taps or standpipes, tube wells or boreholes, protected dug wells, and protected spring, rainwater, and bottled water (Central Statistical Office 2016).

especially in rural areas, rely on unprotected shallow wells, hand-dug wells, and streams, rivers, and lakes, for their supply of drinking water (Central Statistical Office 2011).[6]

We focus on the Luapura Province as a case study of rural Zambia, an area that suffers from lower access to safe drinking water (Figure 1). The Luapula Province is located in the Northern territory of the country and has one million population in an area of 30 thousand square kilometers (Central Statistical Office 2011). Luapula province is economically isolated from the rest of the country and the poverty rate was the highest (80.5%) among the provinces in 2010 (Central Statistical Office 2011). The poverty rate worsened to 81.1% in 2015, the second highest among provinces and higher than the national average of 54.4% (Central Statistical Office 2011). Access to safe water in the Northern provinces including the Luapula Province was the lowest at 30.8% in 2015, a situation which, surprisingly, had registered no improvement from 2010.

Geographically, more than 40% of the Luapula Province area is occupied by lakes and wetland areas (JICA 2011) including Lake Bangweulu in the southeastern corner, Lake Mweru in the northwestern corner and the Luapula River (Figure 1). Despite these rich water sources, the proportion with access to safe water in the Luapula province was among the lowest, only 28% in 2010, but had substantially improved to 52.9% in 2015 (Central Statistical Office 2016).

[6] More than 90% of the households used water from unsafe sources for drinking and daily use and most of the people were dissatisfied with their water sources in the survey area (JICA 2014).

(2) Prevalence of waterborne disease

Diarrhea is among the top ten major causes of morbidity in Zambia and a higher incidence has been observed in more recent years. There is a growing concern that lack of access to safe water is a major cause of waterborne diseases, including diarrhea. The incidence of diarrhea was on an increasing trend by 2014, the most recent data available (Ministry of Health, Republic of Zambia 2014). The national average of the incidence of diarrhea per one thousand population increased from 6.9 percent in 2008 to 8.6 percent in 2012, implying the population's water-related health status was deteriorating.[7] The government points out that this increase in incidence may be attributed to poor access to protected water points and inadequate clean water sources as well as lower accessibility to and under-utilization of chlorine, and called for improvement in the home treatment of water at the community level (Ministry of Health, Republic of Zambia 2014). On the other hand, the hospital case fatality rates for diarrhea slightly decreased from 74 deaths per 1,000 admissions in 2010 to 65 in 2012.[8] By age group, the care fatality rates for children under age 5 decreased from 78 deaths to 49 deaths while those for children aged 5 and over increased from 67 to 83 during these two years.

Turning to Luapula, the incidence of diarrhea declined from 7.2% in 2008 to 6.0% in 2010 but increased again to 8.3% in 2012, slightly below the national average. The hospital case fatality rates deteriorated from 54 deaths per 1,000 admissions in 2010 to 69 deaths in the same period (Ministry of Health 2014). The Luapula Province

---

[7] Diarrhea (non-bloody) incidence is defined as the number of new cases of diarrhea (non-bloody) per 1,000 population over one year.

[8] Diarrhea (non-bloody) case fatality rate (CFR) is defined as the number of deaths due to diarrhea (non-bloody) per 1,000 admissions of diagnosed diarrhea (non-bloody).

is therefore recognized being at high risk of waterborne diseases as it has many untreated and easily contaminated water sources in the large number of rivers, streams, and lakes, and hygiene is very poor particularly around fish markets along the Luapula River (JICA 2014).

(3) School attendance

The national average of school attendance rates in Zambia in 2015 was 29.8% for pre-primary school age children (5-6 years old), 83.1% at primary school age (7-13 years old), 75.7% at secondary school age (14-18 years old), followed by 29.4% at the higher education age (19-22 years old) (Central Statistical Office 2016). There is a large disparity in school attendance between rural and urban areas, and this is wider in higher education. The figure was lower in the rural area at any education level; 18.2% at pre-primary school age, 79.1% at primary school age, 72.7% at secondary school age and 25.4% at the tertiary education level. Between 2010 and 2015, school attendance rates increased for pre-school age groups and for higher educational level groups but slightly declined for other school levels over the period.[9]

We observe a gap in school attendance by gender. While the attendance rate was higher for girls (84.8%) than boys (81.3%) at primary school and pre-primary school (28.2% for boys and 31.4% for girls), the attendance rate was consistently higher for boys than girls at the higher education level; 78.4% at secondary school for boys (73.4% for girls) and 36.3% for males aged 19 to 22 years old (22.5% for their female

[9] Other measures also show a lower rate of school attendance in the Luapula province. The gross attendance rate was 91.7% at primary school and 50.5% at secondary school. Those figures were below the national average; 104.1% at primary school and 64.4% at secondary school. The trend is the same in the net attendance rate; 65.3% in Luapula (78.6% in all of Zambia) for primary schools and 31.8% in Luapula (43.7% in all of Zambia).

counterparts) (Central Statistical Office 2016). Moreover, we see an income gradient in school attendance. The primary (secondary) school attendance rates for extremely poor, moderately poor and non-poor persons were 69.4% (23.7%), 75.8% (28.7%) and 82.2% (33.5%), showing that the gap has widened for secondary school attendance. While primary school attendance rate for extremely poor persons was 70.1% in rural areas and higher than 65.1% in urban areas, the rate was reversed for moderately poor persons; 75.4% in rural areas and 78.9% in urban areas.

School attendance in Luapula was lower than the average in other rural areas in Zambia; 14.6% of pre-primary school age students, 70.9% at primary school age, 72.4 % at secondary school age and 25.4% at higher level education.

(4) The groundwater development project by JICA

Together with other donors, JICA (Japan International Cooperation Agency) made progress on several projects to improve access to safe water in the Luapula Province. JICA provided grant aid assistance to the Zambian Government to construct 200 water facilities with hand pumps in all seven administrative districts in Luapula Province (Project for Groundwater Development in Luapula Province Phase 1). The project supplied about 50,000 people, which corresponds to 5 percent of the population in the province, with access to safe water and technical cooperation on the operation and maintenance of existing water facilities.[10]

The target project in this study is the second phase of the grant aid project for

[10] The United Nations Children's Fund (UNICEF), African Development Bank, Water Aid, and Plan International also constructed water facilities and provided training for persons in charge of operation and maintenance of facilities, which increased substantially the proportion of the population with access to safe water from 11.1% in 2006 to 28.0% in 2010 (Central Statistical Office 2011).

groundwater development in Luapula Province financed by JICA (Project for Groundwater Development in Luapula Province Phase 2) conducted in four districts of the province; Nchelenge, Mwense, Mansa, and Milenge. This project aimed at reducing water-related diseases, especially diarrhea, by assuring reasonable access to safe and stable water sources. The project consists of hardware and software components. The hardware component is the construction of borehole water supply facilities with hand pumps at 216 sites. Construction started in February 2012 and was completed in May 2013, and the first facilities were handed over and residents started to use them in October 2012. The distinct feature of the facilities in the project is the depth of the boreholes. These have a designed average depth of 63 meters from the ground (the minimum depth is 30 meters), which ensures that water is free from ground contaminants (JICA 2014). The quality of water at each borehole was tested to satisfy the national standards of Zambia before each facility was handed over to the residents.[11] The water was not contaminated at all at the source at least on completion and thus the examination in this study is exempt from any possibility of potential contamination at source. Each facility was designed to provide 30 liters of water for 250 people (7500 liters of water) per day and the project was expected to benefit more than 54,000 people in the four districts in total (JICA 2014).

The following procedure was conducted at all target sites including those where a facility was not constructed due to drilling failure. After project orientation and giving consent to participating in the project, villagers were required to join in village meetings

[11] The test of the quality of the water included examination of electrical conductivity, pH, contents including iron, manganese, fluorine, and the existence of E. coli. The testing was conducted on-site, and any suspicious samples were reexamined further at the laboratory of the University of Zambia in Lusaka (JICA 2014). An iron remover was installed to reduce the iron content found to exceed the reference value at three sites, however these are not included in the sample in this study by chance.

to decide where water facilities were to be constructed. The final drilling points were selected using hydrogeological conditions data derived through careful field reconnaissance and geophysical sounding, but priority was given to the local residents' demands based on population and the possibility of groundwater contamination (JICA 2014). This activity was followed by (re-)organization of the Village Water, Sanitation and Health Education (V-WASHE) Committee, which is responsible for general and daily operations and maintenance at the village level. The activities of the V-WASHE committee include minor repairs, collection of maintenance fees, and communication with the administration or the Area Pump Menders (APMs).[12] In addition, a variety of training programs were provided to stakeholders.[13] Those program offered knowledge and techniques for the operation and maintenance of the facilities and management of organization for V-WASHE members and administration officers, and promoted hygiene and sanitation practices at the target sites for villagers. These activities were intended to improve the proper understanding of health and sanitation by enhancing proper hygiene behavior and by facilitating resident ownership of the facilities and their commitment to maintenance activities (JICA 2014).

(5) Project site selection

The target sites in the project were selected as follows. First, 320 sites in the four districts (Nchelenge, Mwense, Mansa, and Milenge) were specified by the Government of Zambia in its request for grant aid. Then, each specified site was screened using a

[12] APMs are responsible for maintenance and repairs of the facilities that communities cannot handle for a fee. One or two people in each ward are assigned as APMs and provided with repair kits by the project (JICA 2014).

[13] The software components include capacity-building workshops for V-WASHE members to acquire knowledge and techniques for the operation and maintenance of the facilities and management of the organization. Moreover, training at the district level is provided so that district officers, WASHE facilitators, and APMs can offer V-WASHE members administrative and technical support.

preparatory survey of seven criteria to consider the feasibility and relevance of the project implementation.[14] After careful examination, 291 sites were found to satisfy the criteria and were identified as candidate sites. Then, 216 sites were selected as the target sites for this project based on their population size. The remaining 75 sites served as alternatives when drilling was unsuccessful at target sites because there was still a risk of failure to find underground water. A maximum of two drillings were attempted at a site, and if both were unsuccessful, the site was cancelled and replaced with one of the alternative sites (JICA 2014). In the end, the project constructed 216 facilities at 214 sites, but 31 target sites were replaced because it was impossible to obtain groundwater even after two drillings. In Milenge district, two additional facilities were constructed at two sites since the number of unsuccessful sites exceeded the number of alternative sites (JICA 2014).[15]

## 3. Data description

The data used in this study consists of the results of two rounds of survey. The first round (baseline) was conducted during June to July 2012, and the second round (end-line) was conducted during June to August 2013, both being implemented by an independent local consulting firm hired by JICA Zambia Office. The timing of both surveys were implemented in the dry season (April to October in Zambia) within the almost no rain period (June to August) because it is practically impossible to travel on the roads in the project area in the rainy season (JICA 2014).

[14] The seven criteria are: (1) demand for safe and stable water supply; (2) accessibility to the site; (3) hydrogeological conditions; (4) availability of existing water supply facilities; (5) overlap with other related projects; (6) possibility of forming a V-WASHE Committee; and (7) residents' willingness to pay the operation and maintenance costs of the facilities.

[15] Those two sites were not included in this study by chance.

The survey was conducted in three districts (Milenge, Mwense, and Nchelenge) of Luapula Province.[16] At the baseline survey, in Milenge district 14 target sites were randomly selected from the list of the villages where the project was to be implemented as treatment group. Then, from the list of the villages where the project was not to be implemented, 12 control sites were purposefully selected as a control group by examining demographic and socio-economic conditions of the villages so that we could have treatment and control groups with similar underlying attributes. The total number of sample sites in Milenge was 26. In addition, 19 target sites and 17 control sites were chosen in Mwense district (36 in total), and 17 target sites and 15 control sites were chosen in Nchelenge district (32 in total). The total in the sample was 94 sites.

However, the project was not able to obtain water from new boreholes at some target sites because they did not strike water bearing strata. We should note here that it is very difficult to predict the possibility of obtaining water successfully when blind-boring. Those sites without water could however be regarded as control sites at the end-line survey, and new sites converted from control sites into target sites where it was possible to get water from new boreholes. In other words, given the total number of target and control sites, some target sites were converted to control sites and vice versa, depending on the success of obtaining groundwater. After those conversions we ended up with 21 “project sites" with water access and 5 control sites without water access in Milenge, 25 project sites and 11 control sites in Mwense, and 18 project sites and 14 control sites in Nchelenge. The conversions resulting from the unexpected failures eventually created an ideal situation for impact evaluation because we could regard this

[16] While the sites of the project initially included Mansa, the district was excluded from the survey since the facilities in some sites were handed over to the villagers before the baseline survey.

situation as being if the construction of the new borehole had been randomly assigned to the project sites.

For the baseline survey in each sampled village, 8 households were randomly selected and thus 752 households in total across the 94 sites were interviewed. 117 households (15.6% of the total) were dropped from the sample and could not be revisited in the end-line survey. The total number of households that were surveyed both at baseline and end-line was 635 (434 households in the treatment group and 201 households in the control group).[17] Table 1 reports the decomposition of the number of households by rounds and districts. We make two remarks on the interval of two rounds of the survey. One is that the interval is short (only one year), which enables us to examine the short-term impact of safe water access on a variety of outcomes. The other is that no facilities were available at the timing of the first survey in the sample sites. Those facilities were constructed between February 2012 and April 2013 and villagers started to use the first facilities in October 2012 in the sample sites. Villagers living around different sites started to use them at different times and the period to use new facilities in the project sites averaged 6 months (varying from 2 months to 10 months).

Both rounds of the survey employed household and community questionnaires and these contained a wide variety of socio-economic variables of individuals, households, and communities.[18] The same questionnaire was used in both surveys with minor revisions after another pretest in the end-line survey. The survey demonstrates three distinct features. First, access to exiting water sources outside houses was

[17] Households with fewer family members were more likely to move away but this attrition pattern did not significantly differ between project and control sites (JICA 2014).

[18] The questionnaires were tested twice to validate the contents and revised prior to the first-round survey (JICA 2014).

confirmed by both community and household questionnaire. The community questionnaire checked the presence of existing water sources in the community and also their accessibility and the household questionnaire asked respondents to provide information about the distance from their house to each water source and the practice of fetching water per day from each water source for the day before the interview.

Second, a simple test of the quality of drinking water stored at each household was conducted by the enumerators. They took a cup of water from a storage container in the house and tested its sheet to see whether the drinking water contained a certain amount of Escherichia coli (E.coli).[19] The household questionnaire collected information about episodes of illness/injury for each individual family members over the past 30 days as well as any diarrhea-related symptoms over the past two weeks and over the past 30 days. Third, the survey collected detailed use of time information and asked respondents to fill in a timetable for a whole day by 18 types of activities.[20] The detailed time use survey allowed us to measure the time spent on a variety of activities including that spent on water collection and to understand comprehensively the impact of improved access to pure water sources on behavioral changes in children, which is better than the simple questions on involvement or time spent water collection frequently used in other studies.

In Table 2, we preview the main variables used in this study. The upper part of Table 2 shows the means of the proportion of those who had diarrhea in the last 14 days

[19] Escherichia coli (E. coli) is one of the indicators of water quality and the appearance of spots on the test sheet indicated that the drinking water of the household was contaminated. The test results were independently judged by an enumerator and a supervisor and the project manager made a final judgment when they disagreed with the results.

[20] The most knowledgeable person was made responsible to provide information on use of time but when they were absent their spouses were responsible for the responses. The activities recorded in the time use survey are presented in Table 3.

(2 weeks) among children aged 6 or less and among children aged 7 to 18. Each cell shows the mean incidence of diarrhea symptoms in the project sites and control sites during the baseline survey (2012) and in the follow-up survey. For pre-school children, the incidence in the project sites declined from 5.7 percent at baseline to 3.3 percent at follow-up while the incidence in the control sites increased from 4.8 percent at baseline to 6.8 percent at the follow-up survey. The difference in difference mean is a 4.3% decline in the project sites, which is significantly different from zero. For school age children, however, the incidence is comparable between in the project and control sites; the incidence declined from 1.4% to 1.1% in the project sites and from 1.5% to 0.9% in the control sites and the difference in difference of the means is 0.2%, which is not significantly different from zero. These simple computations suggest that the improved access to safe water at newly built boreholes may contribute to a decline the incidence of diarrhea symptoms for children aged 6 or less but not for those aged 7 to 18.

The lower part of the table reports the difference in difference estimates for current school attendance by girls and boys aged 7 to 18. For girls, the proportion of those who currently attending school in the project sites declined from 79.7% at baseline to 65.9% at follow-up and that in the control sites also declined from 74.5% at baseline to 69.3% at the follow-up survey. The difference in difference in the mean is minus 8.6%, showing that the decline is larger for girls in the project sites. For boys, the school attendance rate declined from 85.0% to 71.9% in the project sites and declined from 76.2% to 71.3% in the control sites. The difference in difference mean is a negative 8.1%, implying that the decline is larger for boys in the project sites. Both results imply that improved access to safe water may worsen school attendance both for girls and boys, though the difference in difference estimate is not significantly different from zero. Note that those computations do not control for any covariates including individual, household and district characteristics, which are further examined below in the estimation.

Table 3 reports on the time allocation for girls and boys aged 7 to 18, separately. The upper part of the table shows the time spent on each of 18 activities between 5 am to 10 pm on a weekday by girls. They spent 0.91 hours on fetching water in the project sites at the baseline and the water collection time was reduced to 0.44 hours at the end-line. On the other hand, girls spent 1.15 hours on water collection in the control sites at the baseline and the time spent decreased to 0.45 hours at the end-line. The main reason for the substantial reduction of time on water collection is that many water sources were built between the baseline and the end-line in both the project and control sites and the timing of the end-line lagged into August when most of villagers started agricultural work. The difference in difference mean is 0.23 hours which is significantly different from zero, showing that time spent on fetching water increased for girls at the project sites. In other words, time on fetching water was reduced in the project sites in absolute terms but the reduction is larger at the control sites and, as a result, contrary to expectation, fetching water time increased at the project sites in terms of the difference in difference estimate. We observe a similar pattern in time spent on washing/cleaning and cooking. The time on washing/cleaning or cooking decreased from baseline to end-line in both project sites and control sites but the reduction is larger in the control sites. As a result, the difference in difference mean is positive and significantly different from zero at the project sites. In contrast, time spent on other household chores and travel/walking/commuting decreased for girls in the project sites while it increased for those in the control sites. Consequently, the difference in difference in mean is negative and significant in the project sites. The time on income generating activities increased in the project sites, yet increased more in the control sites resulting in the difference in difference mean being negative and significantly different from zero. There are no activities other than the above-mentioned activities whose difference in difference estimate is significantly different from zero. Time on taking care of children/older people increased in the project sites while it slightly decreased in the control sites. Time on school and homework, which is the most time consuming among the activities, decreased at the project sites while it slightly increased at the control sites. Time spent on leisure, relaxing and resting increased substantially by more than one hour for both project and control sites.

For boys, the trend on time spent in each activities are more in parallel between project and control sites. Their fetching water time, smaller than that of girls, decreased further at both sites between the baseline and end-line surveys. Washing/cleaning time is comparable with that of girls and decreased at both sites. Cooking time, which is very short, decreased at both sites but the decline was larger at the control sites, resulting in a longer time at project sites, and this is significantly different from zero. The time spent on school and homework is comparable with that of the girls but time on social/community activities is different: time on these activities declined at both project and control sites but the decline is larger at the control sites and the difference in difference mean is positive and significantly from zero. Leisure, relaxation and resting time increased substantially between the two rounds of the survey at both sites however, a situation that is also observed in the girls' time allocation.

Those observations show that the newly built boreholes seem to increase time spent on fetching water, washing/cleaning, and cooking while reducing time on other household chores, income generating activities, and travel/walking/commuting time. Time allocation seems to be affected more for girls than boys by the project. In a similar way to the data presented in Table 2, the simple difference in difference mean does not control for any covariates including individual, household and district characteristics, and this is therefore further examined below in the estimation.

Table 4 reports on the summary statistics of the variables used in the estimation. The sample is confined to households which were surveyed in both baseline and end-line periods. The number of households is 635 in both years and the number of children under 18 is 1873 at the baseline and 1732 at the end-line. Looking at individual characteristics, the proportion of females is slightly over half and their average age is 8 years. Turning to household characteristics, the proportion of female headed households is about 20% and the age of head of household is about 43. The highest years of schooling among females above 18 is about 5 years, which is lower than that among males above 18 (about 7 years). The number of household members is about 5. The proportion of dependent members whose age is younger than 15 or older than 65 is about 45%. The monthly real consumption per capita using the adult equivalence scale is 156 and 185 thousand Zambian kwacha in 2012 and 2013 respectively[21], while the value of durable assets is 1.4 and 1.8 million Zambian kwacha in 2012 and 2013 respectively. The figures from 2013 give information on the project. The proportion of households at the project sites is close to 67.6% and 78% of those households used newly built boreholes. In other words, about 80% of the households used the new

[21] 1 US dollar was equal to 5.2 thousand ZMK as of June 2012. The equivalent scale is based on Townsend (1994): the educated guesses for age-sex weights are: for adult males, 1.0; for adult females, 0.9. For males and females aged 13-18, 0.94, and 0.83, respectively; for children aged 7-12, 0.67 regardless of gender; for children 4-6, 0.52; for toddlers 1-3, 0.32; and for infants 0.05.

boreholes but the remaining households did not. Among the users, the average distance to the new borehole is about two hundred meters from their house and it takes about four minutes walking to reach the new water facility. Village characteristics (population and average asset per household) are also shown in the table.

## 4. Empirical strategy

This study employs a difference-in-differences (DID) approach to estimate the impact of the project. The DID methodology combines before/after and with/without comparisons. The central assumption for the DID methodology to be valid is the "parallel trend." We assume that any change between baseline and end-line surveys without the intervention caused by unobserved characteristics is common between the project and control sites. Under the "parallel trend" assumption, the DID methodology can identify the impact of the project by subtracting the common trends from the change at the treatment sites. In our case, there is a level of uncertainty about obtaining access to safe water in advance since there is a risk of failure to find underground water even with careful prior examination so, when this is the case, we replaced the target site with a control site. The risk of failure and replacement policy helped to assure the validity of the parallel trend assumption because they created circumstances identical to the situation where the construction sites had been randomly determined.

To confirm whether any of the observed characteristics are not biased for both sites, we perform a balance test at the baseline before the intervention of the project and compare the variables used in the estimation between the project and control sites. It is desirable for the parallel trend assumption that people in both sites lived in similar circumstances before the project started. We confirm that there is no statistically significant difference in all variables used in the estimation between project and control sites, except during the highest years of schooling among females where this group is significantly larger in the project sites although the magnitude in the difference is small (0.7 years) (Appendix Table). We also need to confirm a balance at the village level of the characteristics between project and control sites. The project sites might have larger populations than the control sites because one of the most important criteria for a village to be a target site is its population, which determines the demand for water. We do not see a significant difference in population between project and control sites.[22]

We examine the impact of the project on the binary outcome variables on incidence of diarrhea and school attendance, and the continuous variables on the use of time on specific activities and the practice of fetching water per day. The basic specification is as follows:

$$Y_{ijt} = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot S_j + \beta_3 \cdot (S_j * t) + \epsilon_{ijt} \qquad (1)$$

Where: *i* refers to a household (or individual), *j* points to a site (or village) and *t* is time ($t = 0$ for baseline and $t = 1$ for end-line). $Y_{ijt}$ is the dependent variable and takes four forms; First, $Y_{ijt}$ is a binary variable that takes the value 1 if a child had diarrhea in the past two weeks and 0 otherwise. Second, $Y_{ijt}$ is an indicator that takes the value 1 if a child attends school currently and 0 otherwise. Third, $Y_{ijt}$ is a continuous variable of time in hours spent on a variety of activities. Fourth, $Y_{ijt}$ is a continuous variable of water volume in litres carried and the number of trips for fetching water at 1 day before

[22] We further confirmed that residents in the project and control sites had similar access to natural resources such as water and firewood and that their communities had similar infrastructure conditions such as roads, irrigation, and electricity as well as similar access to shops/markets, schools, and health facilities at the time of the baseline survey.

the interview. Turning to the right hand side variables, $S_j$ is a binary variable that takes the value 1 if the site has a successful borehole and 0 otherwise. $\beta_0$ to $\beta_3$ are the parameters to be estimated. $\beta_3$ is the parameter of our interest and measures the impact of the project on the outcomes. $\epsilon_{ijt}$ is a well-behaved error term. We employ an ordinary least squared (OLS) estimation to obtain the coefficients. Since a binary variable is the dependent variable for incidence of diarrhea and school attendance, our specification is a linear probability model (LPM) in these cases.

The parallel trend assumption in the DID methodology may be violated if changes in covariates are not common between the project and control sites. Thus, we also employ an empirical model with some covariates since we need to examine if this is the case. The covariates takes two forms; $X_{ijt}$ is a vector to include a set of household (individual) characteristics and $X_{jt}$ is a vector containing a set of site *j*'s characteristics other than success of facility construction ($S_j$). $X_{jt}$ contains dummy variables that capture district-level fixed effects and $X_{ijt}$ contains two dummy variables that capture seasonal differences in the survey months July or August, with reference to June. By adding those covariates, we write another version of our empirical model:

$$Y_{ijt} = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot S_j + \beta_3 \cdot (S_j * t) + X_{ijt}\gamma_1 + X_{jt}\gamma_2 + \epsilon_{ijt} \qquad (2)$$

Where: the notations are same as in (1) except that $\gamma_1$ and $\gamma_2$ are vectors of the parameters to be estimated.

We need to be careful to interpret the coefficient $\beta_3$ that measures the impact of the project on the outcomes since not all households in the project sites report that they used the newly built project boreholes. Thus, those models estimate the intention-to-treat (ITT) impact of the project at the village level to measure the impact of new facilities in the village. The direct impact of new boreholes by the project is captured by examining the effect on borehole users. Therefore, we also employ the following specifications:

$$Y_{ijt} = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot U_i + \beta_3 \cdot (U_i * t) + \beta_2^e \cdot NU_i + \beta_3^e \cdot (NU_i * t) + X_{ijt}\gamma_1 + X_{jt}\gamma_2 + \epsilon_{ijt} \quad (3)$$

Where: the notations are same except for replacing $S_j$ to $U_i$ s and $NU_i$. $U_i$ is a binary variable that takes the value of 1 if the household used a borehole at the project site and 0 otherwise. $NU_i$ is a binary variable that takes the value of 1 if the household does not use a borehole at the project site and 0 otherwise. $\beta_3$ in Specification (3) captures the direct effect while $\beta_3^e$ caputres a spillover effect, if any.

Further, we employ the following specification to consider difference in distance from each house to boreholes among borehole users:

$$Y_{ijt} = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot U_i + \beta_3 \cdot (U_i * t) + \beta_4 \cdot (U_i * t * D_i) + \beta_2^e \cdot NU_i + \beta_3^e \cdot (NU_i * t) + X_{ijt}\gamma_1 + X_{jt}\gamma_2 + \epsilon_{ijt} \quad (4)$$

Where: the notations are same as in (3) except for $D_i$ , which stands for distance to the newly constructed borehole. $D_i$ takes two forms; physical distance in kilometers and time t taken in minutes.

All the regression models in the following section control for the covariates at individual, household, and village level as well as with district dummies. All standard errors are clustered at the village level.

## 5. Estimation results and discussion

Table 5 reports the estimation results on the incidence of diarrhea symptoms over the last two weeks in children. The left hand side reports those for children aged 6 or less and the right hand side shows those for children aged 7 to 18. We focus on the coefficients of our interest; the interaction term between project sites (or borehole users) and the year dummy (end-line). Column (A), which uses Specification (2), shows that the coefficient is negative and significant, thus the incidence of diarrhea is significantly reduced in the project sites by 5.0 percentage points for children aged 6 or less. Column (B), which uses Specification (3) reports that the coefficient is -0.061 and significantly different from zero, implying that the incidence of diarrhea is significantly reduced among households using boreholes (by 6.1percentage points for children aged 6 or less).

Columns (C) and (D) report the result using Specification (4) by adding a new interaction term between borehole use and the year dummy and distance from house to the borehole. The distance is measured in physical distance in kilometers in Column (C) and time in minutes in Column (D). The coefficient on the interaction term between households using boreholes and a end-line year dummy are negative and significant at minus 6.5 and 6.1 percentage points, respectively, a result which is comparable with Column (A) and (B). The coefficients on the added interaction terms are not significant, showing that distance to borehole is not significantly associated with incidence of diarrhea. In contrast, the coefficient of the main explanatory variable is negative but not significant for children aged 7 to 18 (Column (E) to (H)), implying that the newly built boreholes did not contribute to the reduction of diarrhea for those children. The coefficients on the interaction term with distance to boreholes are negative but not significant (Columns (G) and (H)).

Those results confirm the positive and distinct impact on reduction of diarrhea by improved access to safe water at new boreholes for pre-school children aged 0 to 6 but not for children aged 7 to 18. The positive impact of improved access to safe water for children aged under 6 is consistent with Kremer et al. (2011), for instance, that spring protection significantly reduces diarrhea for children under age three. We therefore suggest that our positive results can be attributed to the quality of water in the project. The distinct feature of the project in this study is that water is obtained from very deep boreholes and confirmed to be free from a variety of physical, chemical and biological contaminants. The supremely high quality of this water contributes to the reduction of the incidence of diarrhea in a short period of time after handover to residents. Moreover, we need to be cautious in interpreting the insignificance for school age children. The incidence of diarrhea for those children is much lower than pre-school age children. However, parents may not know all the symptoms of diarrhea or overlook them while children attend school. In other words, it is possible that the incidence of diarrhea is underreported in school age children, which may reduce the impact of improvements in safe water access.

Table 6 reports on the estimation results relating to school attendance for children aged 7 to 18. The left hand side reports the results for girls and the right hand side shows those for boys. We focus on the coefficients of our interest, those relating to the interaction term between project sites (or borehole users) and the year dummy indicating the end-line. Column (A) and (B) show that the coefficient is negative but not significant, indicating that girls' school attendance did not improve at the project sites or among borehole users. Column (C) and (D) add an interaction term between borehole use and the year dummy and the distance from house to the borehole. In Column (C), the coefficient on the interaction term between households using boreholes and the end-line year dummy are negative and significant, which means that girls' school attendance is unexpectedly and significantly reduced among borehole users living close to a borehole. Moreover, the interaction adding distance to borehole is positive and significant, showing that the school attendance for girls increases when a house is located far from a borehole. Put differently, girls' school attendance is the lowest in households neighboring boreholes suggesting that girls living in these households enjoy the benefit of improved access to safe water are less likely to attend school. When we perform a joint test of the sum of the main interaction term and that adding distance, we found the negatively significant effect is on girls living within 100 meters of boreholes (the average distance from boreholes is about 200 meters). In contrast, the coefficients of the explanatory variable of interest are negative but not significant for boys (Column (E) to (H)), implying that boys' school attendance is not associated with the newly built boreholes, unlike that of girls.

Those results shows that improved access to safe water at new boreholes did not stimulate school attendance for both girls and boys and it may even exacerbate lower school attendance for girls living near the boreholes. While an adverse effect is observed for girls living in the surroundings of boreholes, we do not consider that the new water facilities decisively discouraged girls from attending school. Instead, we suggest that the new boreholes did not improve girls' school attendance, which is consistent with most of the previous literature on the topic. We examine the impact of the project on other school outcomes such as educational progression and attendance days and we did not find negative and significant impacts.[23] Moreover, the proportion of school children to repeat a year is high in rural Zambia and more than a half of the boreholes constructed by the project were handed over to residents after January when school starts. The average months to use the new boreholes is 6, which may be too short to change children's behavior towards attending school.

To understand the mechanism behind the different impacts on schooling between girls and boys, we further investigate any changes in time allocation by girls in contrast to boys. Table 7 reports the impact of new boreholes on time spent on schooling and homework. Columns (A) and (B) report the coefficients for girls using Specification (2) and (3), respectively. The coefficient on the main explanatory variable is negative but not significant. Columns (C) and (D) report the coefficients using Specification (3) by adding a new interaction term between borehole use and the year dummy, and the distance from house to the borehole. Then, the coefficient on the main explanatory variable is negative and significant, and the coefficient on the main explanatory variable adding physical distance to borehole use is positive and significant in Column (C), showing that girls spent more time on schooling and homework when their house is located far from the borehole. In other words, girls spent less time on schooling and homework if they live near boreholes, consistent with the data revealed in Table 6. Columns (E) to (H) report the coefficients for boys. We do not see any significant coefficients and we find that the new boreholes did not change time on schooling and homework for boys.

---

[23] The results are available upon request from the authors.

Table 8 reports the impact of new boreholes on the time taken to fetch water. Apart from change in parents' behavior, there are two channels if boreholes by the project affect school attendance positively. One is improvement of health status by reducing the incidence of diarrhea, which is not confirmed for school age children in Table 5. The other is the time gained by shrinking the time taken to collect water, which is investigated here. Column (A) to (D) report the estimation results for girls. All the coefficients on the main explanatory variables with and without the additional interaction terms relating to distance are positive though they are estimated imprecisely. Column (E) to (H) show the estimation results for boys. Again, we do not see any significant coefficients with and without the additional interaction terms with distance.

By the construction of boreholes through the project, villagers are able to gain access to safe water near their houses.[24] Thus, water collection time per round is surely reduced compared to before the new boreholes were set up. At the same time, households may increase their demand for supremely safe water available at boreholes with easier access. If this is the case, total time on fetching water may not be reduced because the number of rounds to collect water increased.

To provide the evidence to support this conjecture, Table 9 explores the impact of new boreholes on the total volume of water carried from various sources and the number of trips made to fetch water at the household level.[25] The coefficients in

[24] At the baseline survey, the average of the minimum distance to water sources used by the sampled households was 493 meters, which was reduced to 265 meters at the end-line survey in both project and control sites. In the project sites, it was reduced from 465 meters to 192 meters mainly due to the construction of JICA boreholes. In the control sites, it was reduced from 554 meters to 416 meters. The decrease in the control sites was due to the construction of boreholes by other agencies and also construction of hand-dug wells by villagers themselves.
[25] An additional analysis confirms that the borehole users on average carried approximately 40 liters from the new boreholes by making on average 3 round trips per day.

Column (B) are positive and have magnitudes close to 6, although they are insignificant, suggesting that borehore-user households at the project sites fetched about 6 liters more water per day, whereas the average fetched water per day is approximately 50 to 60 liters in total. The coeffients in Columns (F) to (H) show that, although the impact on the number of trips for fetching water per day was small and insignificant, the borehole-user households at the project sites made more trips for fetching water the day before the survey date. With regard to the previous week, the borehole-user houesholds at the project sites made about 3 times more trips for fetching water, which is statistically significant (Column (K) and (L)). The average number of trips made to fetch water is about 20 times per week. These results provide consistent evidence for our conjecture on the increased demand for safe water and the increased rounds for fetching water from the new boreholes.

We now move to examine the time used on other activities. Table 10 reports on the impact of new boreholes created by the project on the total time spent on other water-related household chores such as washing clothes, cleaning dishes, and cooking. For girls, the coefficient on the main explanatory variable is positive in all columns (A) to (D). This means that girls in households using boreholes spent approximately 0.25 more hours (15 minutes) on other water-related household chores.[26] While water collection time was not reduced, girls spent more time on water-related household chores in total among the borehole users, which may reflect that mothers on the other hand spent less time on household chores including fetching water, which shifted this to a girls' burden. Indeed, using the same dataset, Shimamura et al. (2020) find evidence

[26] By including time for fetching water, we find that girls in households using the new boreholes spent about 0.4 more hours (24 minites) on water-related househol chores, which is stasifically significant.

that adult females in households using boreholes reduce the time spent for water-related household chores including fetching water (see Appendix 2, which is Table 8 in Shimamura et al. (2020)). For boys, most of the coefficients on the main explanatory variable are negative but not significant.

Table 11 reports the impact of the project on time spent on income generating activities. For girls, the coefficient on the main explanatory variable are negative in all columns (A) to (D) and significant in Column (B) and (C). This means that girls in households using the new boreholes spent 0.8 hours less on income generating activities. This is in line with the results in Table 10 which witnessed the longer time spent on water-related household chores. For boys, most of the coefficients on the main explanatory variable are negative and insignificant.

Our findings are summarized as follows. Improved access to safe water at the new boreholes reduced the incidence of diarrhea for pre-school children aged 0 to 6, but not for children aged 7 to 18. The new boreholes did not improve girls' school attendance and had an adverse effect on those living in the surroundings of boreholes, which is in line with past research. We reinforced those findings by detecting any change in time allocation after intervention. Improved access to safe water had girls spending less time on schooling and homework if they live near boreholes. The availability of safe water at the new facilities did not reduce girls' time on fetching water. This is because households using boreholes increased their demand for the supremely safe water available with easier access, and the total time spent on fetching water does not reduce because the number of rounds to collect water increases. Moreover, the time spent on water-related household chores by girls increased while that on income generating activities decreased. These findings, together with the evidence in Shimamura et al.

(2020) on the use of time by adult females, imply that mothers spent less time on water-related household chores including fetching water by shifted this task to the girls' burden.

## 6. Conclusion

We examine the short term impact of improved access to supremely safe water in rural Zambia at newly built boreholes on children in terms of health, schooling and time allocation. We observe positive and significant effects of improved access to safe water on the reduction of the incidence of diarrhea for pre-school children but not for school age children. Our finding on the positive impact for younger children is promising and indicates the purpose of the project was successful. On the other hand, we do not find any positive effect on school attendance and even show the negative effect on children living surrounding new boreholes that is in line with previous studies. The analyses using the time use survey confirms that there is no change in the time spent on fetching water alone, yet there is a significant increase in total time spent on water-related household chores including water collection. In addition, we find a significant decrease in time spent on income generating activities. The mechanism working behind this is that households increased their demand for supremely safe water available at boreholes with easier access and it appears that the burden of water-related household chores shifted from mothers to daughters.

Future research should explore the longer-term effects of the improvement of access to safe water. In doing so, because there exist many foster children especially orphans under African extended family system, the living arrangements of children have to be considered as being influential factors in their time allocations (Yamano et al.

2006). The fostering decisions relating to children in African society are made for the purpose of filling labor demand and/or for educational purposes (Serra 2009). The longer-term effects on the time allocation of school-age children such as who bears the burden of fetching water, particularly as a result of intervention, are highly likely to be heterogeneous depending on such fostering motives.

**References**


Arnold, B., and J. Colford Jr. 2007. "Treating Water with Chlorine at Point-of-use to Improve Water Quality and Reduce Child Diarrhea in Developing Countries: A Systemic Review and Meta-analysis." *American Journal of Tropical Medicine and Hygiene* 76(2): 35–364.

Bevan, D., P. Collier, and J. W. Gunning. 1989. *Peasants and Governments: An Economic Analysis*. Oxford: Clarendon.

Blum, D., N. Robert, S. Emeh, R. A. Huttly, O. Dosunmu-Ogunbi, N. Okeke, M. Ajala, J. I. Okoro, C. Akujobi, B. R. Kirkwood, and R. G. Feachem. 1990. "The Imo State (Nigeria) Drinking Water Supply and Sanitation Project: Description of the Project, Evaluation Methods, and Impact on Intervening Variables." *Transactions of the Royal Society of Tropical Medicine and Hygiene* 84(2) : 309–15.

Cairncross, S., and J. L. Cliff (1987). "Water Use and Health in Mueda, Mozambique," *Transactions of the Royal Society of Tropical Medicine and Hygiene* 81(1) : 51–54.

Central Statistical Office, Republic of Zambia. 2011. *Living Conditions Monitoring Survey Report 2010*. Lusaka: CSO.

Central Statistical Office, Republic of Zambia. 2016. *Living Conditions Monitoring Survey Report 2015*. Lusaka, CSO.

Clasen, T. F., K. T. Alexander, D. Sinclair, S. Boisson, R. Peletz, H. H. Chang, F. Majorin, and S. Cairncross. 2015. "Interventions to Improve Water Quality for Preventing Diarrhoea." *Cochrane Database of Systematic Reviews*, 10.

Devoto, F., E. Duflo, P. Dupas, W. Parienté, and V. Pons. 2012. "Happiness on Tap: Piped Water Adoption in Urban Morocco." *American Economic Journal: Economic Policy* 4(4): 68–99.

Fewtrell, L., R. B. Kaufmann, D. Kay, W. Enanoria, L. Haller, and J.M. Colford Jr. 2005. "Water, Sanitation, and Hygiene Interventions to Reduce Diarrhoea in Less Developed Countries: A Systematic Review and Metaanalysis." *Lancet Infect. Dis*. 5: 42–52.

Graham, J., M. Hirai, and S. Kim. 2016. "An Analysis of Water Collection Labor among Women and Children in 24 Sub-Saharan African Countries." *PLoS ONE* 11(6).

Gross, E., I. Günther, and Y. Schipper. 2018. "Women Are Walking and Waiting for Water: The Time Value of Public Water Supply." *Economic Development and Cultural Change* 66(3): 489-517.

Gundry, S., J. Wright, and R. Conroy. 2004. "A Systematic Review of The Health Outcomes Related to Household Water Quality in Developing Countries." *Journal of Water and Health* 02(1): 1–13.

Günther, I., and Y. Schipper. 2013. "Pumps, Germs and Storage: The Impact of Improved Water Containers on Water Quality and Health." *Health Economics* 22(7): 757–74.

Japan International Cooperation Agency. 2014. *Basic Research for Impact Evaluation Trial on Grant Aid: A Case from Rural Groundwater Development Project in Zambia*. Tokyo: JICA.

Koolwal, G., and D. Van de Walle. 2013. "Access to Water, Women's Work and Child Outcomes." *Economic Development and Cultural Change* 61(2): 369-405.

Kremer, M., J. Leino, E. Miguel, and A.P. Zwane. 2011. “Spring Cleaning: Rural Water Impacts, Valuation, and Property Rights Institutions.” *Quarterly Journal of Economics* 126: 145–205.

Ministry of Health, Republic of Zambia. 2014. *Annual Health Statistical Bulletin* 2012. Lusaka: MOH.

Morrison, A., D. Raju, and N. Sinha. 2007. *Gender Equality, Poverty and Economic Growth*. Washington DC: World Bank Policy Research Working Paper no. 4349.

Nauges, C., and J. Strand. 2017. “Water Hauling and Girls’ School Attendance: Some New Evidence from Ghana,” *Environment and Resource Economics* 66:65–88.

Ray, I. 2007. “Women, Water and Development.” *Annual Review of Environment and Resources* 32:421–49.

Rosen, S., and J. R. Vincent. 1999. *Household Water Resources and Rural Productivity in Sub-Saharan Africa: A Review of the Evidence*. Unpublished manuscript. Harvard Institute for International Development, Cambridge, MA.

Serra, R. 2009. “Child Fostering in Africa: When Labor and Schooling Motives May Coexist.” *Journal of Development Economics* 88: 157-170.

Sorenson, S., C. Morssink, and P. Campos. 2011. “Safe Access to Safe Water in Low Income Countries: Water Fetching in Current Times.” *Social Science and Medicine* 72(9): 1522–26.

Shimamura, Y., S. Shimizutani, S. Taguchi, and H. Yamada. 2020. “Improved Access to Safe Water, Adult Health and Time Reallocation in Rural Zambia.” *Mimeographed.*

Townsend, R. 1994. “Risk and Insurance in Village India.” *Econometrica* 62(3): 539-591.

United Nations. (n.d.) *Sustainable Development Goals, Goal 6 Water and Sanitization*. https://www.un.org/sustainabledevelopment/water-and-sanitation/

United Nations Children's Fund (UNICEF) and the World Health Organization (WHO). 2017. *Progress on household drinking water, sanitation and hygiene 2017*.

United Nations Children's Fund (UNICEF) and the World Health Organization (WHO) 2019. *Progress on household drinking water, sanitation and hygiene 2000-2017. Special focus on inequalities.*

United Nations Educational, Scientific and Cultural Organization (UNESCO). 2020. *Global Education Monitoring Report. Inclusion and Education: All Means All*. Paris: UNESCO. https://en.unesco.org/gem-report/allreports

United Nations Educational, Scientific and Cultural Organization, Institute for Statistics (UIS). 2019. *UIS Fact Sheet No. 56*. Paris: UNESCO. http://uis.unesco.org/sites/default/files/documents/new-methodology-shows-258-million-children-adolescents-and-youth-are-out-school.pdf

Waddington, H., and B. Snilstveit. 2009. "Effectiveness and Sustainability of Water, Sanitation, and Hygiene Interventions in Combating Diarrhoea." *Journal of Development Effectiveness* 1(3): 295–335.

World Health Organization and the United Nations Development Programme. 2007. "Economic and health effects of increasing coverage of low cost household drinking-water supply and sanitation interventions to countries off-track to meet MDG target 10." Background document to the *Human Development Report 2006*. Washington DC: World Health Organization.

Wright, J., S. Gundry, and R. Conroy. 2004. "Household Drinking Water in Developing

Countries: A Systematic Review of Microbiological Contamination between Source and Point-of-Use." *Tropical Medicine and International Health* 9(1): 106–117.

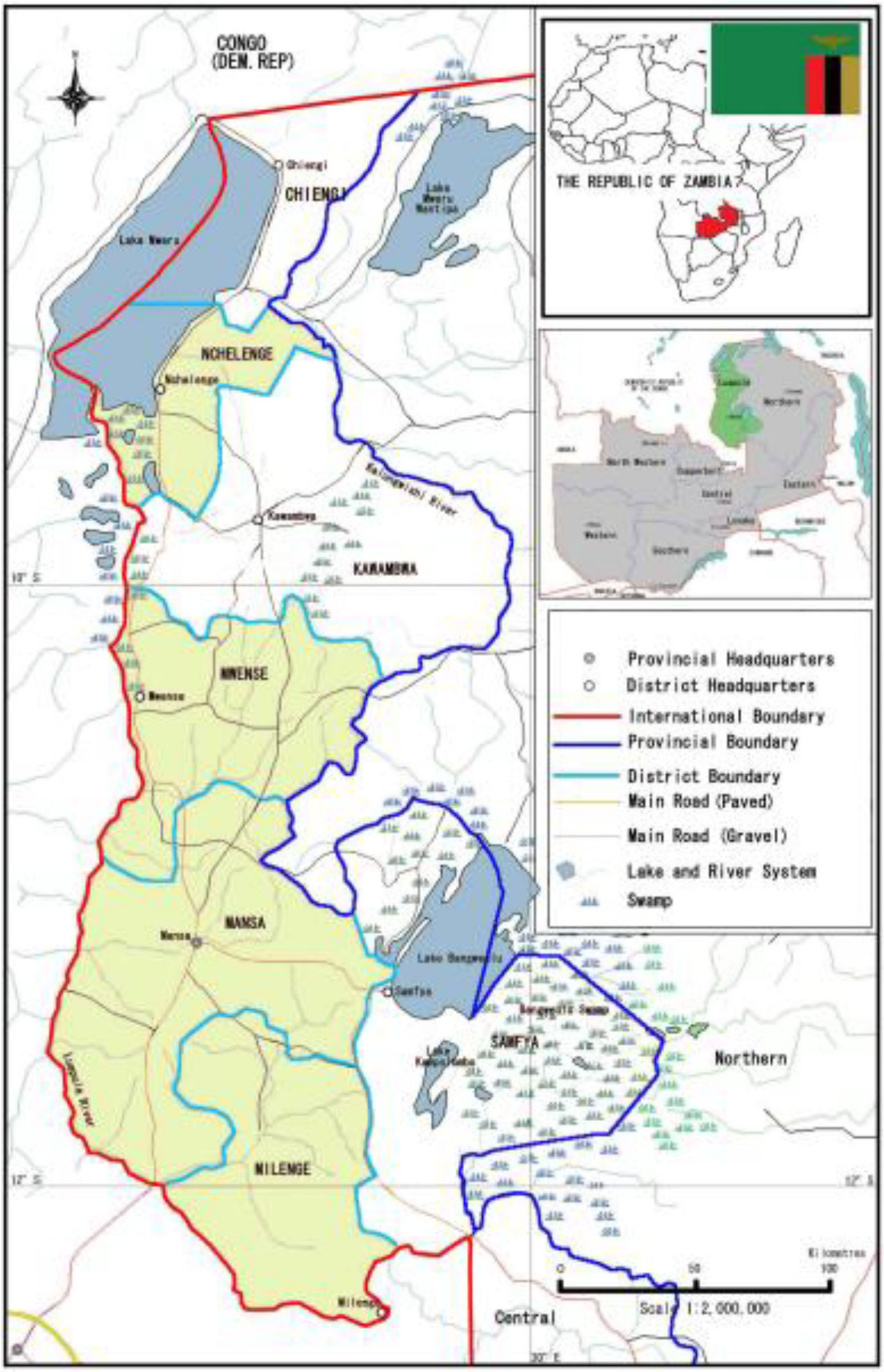
Yamano, T., Y. Shimamura, and D. Sserunkuuma. 2006. "Living Arrangements and Schooling of Orphaned Children and Adolescents in Uganda." *Economic Development and Cultural Change* 54(4): 833-856.

Zhang, J. (2011). "The Impact of Water Quality on Health: Evidence from Drinking Water Infrastructure Program in Rural China." *Journal of Health Economics* 31(1): 122–134.

Zhang, J., and L. Xu. 2016. "The long-run effects of treated water on education: The rural drinking water program in China." *Journal of Development Economics* 122: 1–15.

Zwane, A. P., and M. Kremer. 2007. "What Works in Fighting Diarrheal Diseases in Developing Countries? A Critical Review." *World Bank Research Observer* 22(1): 1–24.

**Figure 1 Map of the Luapula province**




Source: Completion Report of the Project.

**Table 1 The number of households in each district and the survey**

| | Before (2012) | | | After (2013) | | | Attrition rate (%) |
|---|---|---|---|---|---|---|---|
| | Project sites | Control sites | All | Project sites | Control sites | All | |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) |
| Milenge | 168 | 40 | 208 | 150 | 35 | 185 | 11.1 |
| Mwense | 192 | 96 | 288 | 151 | 85 | 236 | 18.1 |
| Nchelenge | 144 | 112 | 256 | 128 | 86 | 214 | 16.4 |
| | 504 | 248 | 752 | 429 | 206 | 635 | 15.6 |

## Table 2 Incidence of diarrhea symptoms and school attendance

| | Before (2012) | | After (2013) | | Diff. |
|---|---|---|---|---|---|
| | (A) | (B) | (C) | (D) | (E) |
| | Obs. | Mean | Obs. | Mean | Mean |
| ***Incidence of diarrhea symptoms among children aged 6 or less*** | | | | | |
| **Project sites** | 510 | 0.057 | 452 | 0.033 | -0.024 |
| **Control sites** | 271 | 0.048 | 237 | 0.068 | 0.020 |
| **Difference-in-Differences** | | | | | -0.043* |
| ***Incidence of diarrhea symptoms among children aged 7 to 18*** | | | | | |
| **Project sites** | 763 | 0.014 | 726 | 0.011 | -0.003 |
| **Control sites** | 329 | 0.015 | 317 | 0.009 | -0.006 |
| **Difference in Differences** | | | | | 0.002 |
| ***School attendence among female children (girls) aged 7 to 18*** | | | | | |
| **Project sites** | 390 | 0.797 | 370 | 0.659 | -0.138 |
| **Control sites** | 161 | 0.745 | 150 | 0.693 | -0.052 |
| **Difference-in-Differences** | | | | | -0.086 |
| ***School attendence among male children (boys) aged 7 to 18*** | | | | | |
| **Project sites** | 373 | 0.850 | 356 | 0.719 | -0.131 |
| **Control sites** | 168 | 0.762 | 167 | 0.713 | -0.049 |
| **Difference-in-Differences** | | | | | -0.081 |

Note: Incidence of diarrheal symptoms over the last two weeks were reported by the respondents of the sampled households. The sample is confined to children in those households that were surveyed in both rounds.
Statistical tests were performed by using the OLS model:; * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

## Table 3 Time allocation in hours from 5am to 8pm (Children aged 7 to 18)

| | *Project sites* | | | *Control sites* | | | **Diff.-** |
|---|---|---|---|---|---|---|---|
| | *Before* | *After* | *Diff.* | *Before* | *After* | *Diff.* | **in-Diff.** |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) |
| ***No. of observations (girls 7-18)*** | 371 | 350 | | 158 | 142 | | |
| Fetching water | 0.91 | 0.44 | -0.47 | 1.15 | 0.45 | -0.70 | 0.23* |
| Collecting firewood | 0.08 | 0.04 | -0.05 | 0.10 | 0.01 | -0.09 | 0.05 |
| Grazing/taking care of animals | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 |
| Washing/cleaning | 0.53 | 0.46 | -0.07 | 0.65 | 0.39 | -0.26 | 0.18* |
| Cooking | 0.17 | 0.15 | -0.02 | 0.28 | 0.13 | -0.15 | 0.13** |
| Taking care of chi1ldren/elders | 0.10 | 0.24 | 0.14 | 0.13 | 0.12 | -0.01 | 0.16 |
| Shopping | 0.03 | 0.01 | -0.02 | 0.01 | 0.00 | -0.01 | -0.01 |
| Collecting grass | 0.04 | 0.01 | -0.03 | 0.00 | 0.00 | 0.00 | -0.03 |
| Other household chores | 1.07 | 0.75 | -0.32 | 0.78 | 0.89 | 0.10 | -0.42** |
| Income generating activities | 0.51 | 0.93 | 0.42 | 0.54 | 1.74 | 1.19 | -0.78** |
| School and homework | 4.06 | 3.59 | -0.48 | 3.99 | 4.03 | 0.04 | -0.51 |
| Travel/walking/commuting | 0.60 | 0.36 | -0.24 | 0.26 | 0.29 | 0.03 | -0.27* |
| Social/community activities | 0.17 | 0.04 | -0.13 | 0.22 | 0.04 | -0.19 | 0.06 |
| Religious activities | 0.07 | 0.16 | 0.09 | 0.02 | 0.00 | -0.02 | 0.11 |
| Eating/drinking | 1.31 | 1.03 | -0.28 | 1.34 | 0.95 | -0.39 | 0.11 |
| Leisure/relaxing/resting | 2.48 | 4.00 | 1.52 | 2.41 | 3.61 | 1.19 | 0.33 |
| Sleeping | 1.60 | 1.56 | -0.04 | 1.48 | 1.41 | -0.07 | 0.03 |
| Other | 1.27 | 1.23 | -0.05 | 1.61 | 0.95 | -0.67 | 0.62** |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) |
| ***No. of observations (boys 7-18)*** | 363 | 337 | | 167 | 157 | | |
| Fetching water | 0.68 | 0.35 | -0.33 | 0.74 | 0.28 | -0.47 | 0.13 |
| Collecting firewood | 0.09 | 0.04 | -0.05 | 0.08 | 0.01 | -0.07 | 0.02 |
| Grazing/taking care of animals | 0.01 | 0.04 | 0.03 | 0.02 | 0.03 | 0.01 | 0.02 |
| Washing/cleaning | 0.54 | 0.34 | -0.19 | 0.51 | 0.30 | -0.21 | 0.01 |
| Cooking | 0.06 | 0.04 | -0.02 | 0.12 | 0.04 | -0.08 | 0.06* |
| Taking care of chi1ldren/elders | 0.03 | 0.20 | 0.16 | 0.07 | 0.39 | 0.33 | -0.16 |
| Shopping | 0.04 | 0.01 | -0.03 | 0.02 | 0.01 | -0.01 | -0.02 |
| Collecting grass | 0.05 | 0.02 | -0.03 | 0.02 | 0.02 | 0.00 | -0.03 |
| Other household chores | 0.86 | 0.57 | -0.28 | 0.73 | 0.32 | -0.41 | 0.13 |
| Income generating activities | 0.52 | 1.11 | 0.60 | 0.49 | 1.59 | 1.10 | -0.50 |
| School and homework | 4.31 | 3.86 | -0.45 | 4.40 | 3.77 | -0.64 | 0.19 |
| Travel/walking/commuting | 0.45 | 0.32 | -0.12 | 0.27 | 0.22 | -0.04 | -0.08 |
| Social/community activities | 0.10 | 0.09 | -0.01 | 0.26 | 0.06 | -0.20 | 0.19** |
| Religious activities | 0.05 | 0.10 | 0.05 | 0.04 | 0.01 | -0.04 | 0.09 |
| Eating/drinking | 1.24 | 0.99 | -0.25 | 1.36 | 1.00 | -0.36 | 0.11 |
| Leisure/relaxing/resting | 2.68 | 4.12 | 1.44 | 2.69 | 4.44 | 1.75 | -0.31 |
| Sleeping | 1.49 | 1.43 | -0.06 | 1.66 | 1.56 | -0.09 | 0.03 |
| Other | 1.79 | 1.34 | -0.45 | 1.51 | 0.94 | -0.57 | 0.12 |

Note: The sample is confined to children in the households which were surveyed in both rounds. Statistical tests were performed by using the OLS model: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

**Table 4 Summary Statistics of explanatory variables**

| 2012 | **Mean** | **s.d.** | **Min.** | **Max.** |
|---|---|---|---|---|
| | (A) | (B) | (C) | (D) |
| ***Individual characteristics*** | | n=1873 | | |
| Female (=1) | 0.507 | (0.500) | 0 | 1 |
| Age | 8.3 | (5.25) | 0 | 18 |
| ***Household characteristics*** | | n=635 | | |
| Female headed household (=1) | 0.200 | (0.400) | 0 | 1 |
| Age of the head | 43.1 | (13.62) | 18 | 84 |
| Highest education (years) among females above 18 | 5.114 | (2.929) | 0 | 12 |
| Highest education (years) among males above 18 | 6.825 | (2.823) | 0 | 12 |
| Household size | 5.203 | (2.365) | 1 | 15 |
| Ratio of dependents to household size | 0.452 | (0.246) | 0 | 1 |
| Monthly consumption per capita (thousand ZMK) | 156.2 | (193.0) | 16.01 | 2780 |
| Value of durable assets (million ZMK) | 1.385 | (1.915) | 0.005 | 29.40 |
| Surveyed in June (=1) | 0.647 | (0.478) | 0 | 1 |
| Surveyed in July (=1) | 0.353 | (0.478) | 0 | 1 |
| ***Village characteristics*** | | n=94 | | |
| Population | 467.3 | (524.9) | 48 | 3360 |
| Average asset per household (million ZMK) | 6.313 | (5.214) | 1.448 | 29.30 |
| 2013 | **Mean** | **s.d.** | **Min.** | **Max.** |
| | (A) | (B) | (C) | (D) |
| ***Individual characteristics*** | | n=1732 | | |
| Female (=1) | 0.505 | (0.500) | 0 | 1 |
| Age | 8.7 | (5.11) | 0 | 18 |
| ***Household characteristics*** | | n=635 | | |
| Female headed household (=1) | 0.195 | (0.397) | 0 | 1 |
| Age of the head | 43.9 | (13.68) | 17 | 85 |
| Highest education (years) among females above 18 | 4.973 | (2.956) | 0 | 12 |
| Highest education (years) among males above 18 | 6.715 | (2.884) | 0 | 12 |
| Household size | 5.409 | (2.349) | 1 | 15 |
| Ratio of dependents to household size | 0.452 | (0.234) | 0 | 1 |
| Monthly consumption per capita (thousand ZMK) | 185.1 | (331.0) | 4.301 | 4093 |
| Value of durable assets (million ZMK) | 1.767 | (3.009) | 0.005 | 47.39 |
| Project site (=1) | 0.676 | (0.469) | 0 | 1 |
| Project site * Borehole user (=1) | 0.526 | (0.500) | 0 | 1 |
| Distance to the new borehole (km) [a)] | 0.206 | (0.213) | 0 | 1 |
| Walking time to the new borehole (min) [a)] | 4.072 | (5.752) | 0 | 60 |
| Surveyed in June (=1) | 0.824 | (0.381) | 0 | 1 |
| Surveyed in August (=1) | 0.176 | (0.381) | 0 | 1 |
| ***Village characteristics*** | | n=94 | | |
| Population | 482.5 | (488.0) | 80 | 3360 |
| Average asset per household (million ZMK) | 8.074 | (6.847) | 1.676 | 55.06 |

Note: The sample is confined to children in the households which were surveyed in both rounds. Monthly consumption per capita is adjusted by using adult equivalence scales and measured in the real team at the price level of 2012. Assets per hosuehold include the value of residence, residential and agricultural land, and durable assets. 1USD was worth approximately 5200ZMK as of June 2012.

a) The figures are calculated based on the information about only borehole users (n=334).

**Table 5 Incidence of diarrhea symptoms over the last two weeks**

| **Dependent variable: Diarrhea incidence (=1)** | **Children 0-6** | | | | **Children 7-18** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Project** | **Borehole use** | | | **Project** | **Borehole use** | | |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) |
| ***Project and year dummy variables*** | | | | | | | | |
| Project site/Borehole use | -0.050* | -0.061** | -0.065** | -0.061** | -0.000 | -0.007 | -0.005 | -0.007 |
| * Year 2013 (=1) | (0.027) | (0.028) | (0.029) | (0.028) | (0.012) | (0.011) | (0.012) | (0.012) |
| Project site * Borehole use | | | 0.018 | -0.000 | | | -0.012 | -0.000 |
| * Year 2013 * Distance (km/min.) | | | (0.051) | (0.001) | | | (0.009) | (0.000) |
| Project site/Borehole use (=1) | 0.012 | 0.010 | 0.009 | 0.010 | -0.000 | 0.002 | 0.002 | 0.002 |
| | (0.017) | (0.019) | (0.019) | (0.019) | (0.009) | (0.010) | (0.010) | (0.010) |
| Project site * Borehole non-use | | -0.014 | -0.014 | -0.014 | | 0.020 | 0.020 | 0.020 |
| * Year 2013 (=1) | | (0.042) | (0.042) | (0.042) | | (0.021) | (0.021) | (0.021) |
| Project site * Borehole non-use (=1) | | 0.020 | 0.020 | 0.020 | | -0.004 | -0.004 | -0.004 |
| | | (0.024) | (0.024) | (0.024) | | (0.011) | (0.011) | (0.011) |
| Year 2013 (=1) | 0.023 | 0.023 | 0.023 | 0.023 | -0.008 | -0.008 | -0.008 | -0.008 |
| | (0.023) | (0.023) | (0.023) | (0.023) | (0.010) | (0.010) | (0.010) | (0.010) |
| ***Individual characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Household characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Village characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R sq. | 0.042 | 0.046 | 0.046 | 0.046 | 0.014 | 0.017 | 0.017 | 0.017 |
| No. of observations | 1470 | 1470 | 1470 | 1470 | 2135 | 2135 | 2135 | 2135 |

Note: Village-level cluster-adjusted standard errors are in parentheses: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.
Distance is measured in kilometers in Columns (C) and (G) and measured in minutes in Columns (D) and (H).

## Table 6 School attendance (children aged 7 to 18)

| Dependent variable: School attendence (=1) | Girls | | | | Boys | | | |
|---|---|---|---|---|---|---|---|---|
| | Project | Borehole use | | | Project | Borehole use | | |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) |
| ***Project and year dummy variables*** | | | | | | | | |
| Project site/Borehole use | -0.073 | -0.071 | -0.151** | -0.094 | -0.062 | -0.067 | -0.054 | -0.035 |
| * Year 2013 (=1) | (0.056) | (0.059) | (0.071) | (0.066) | (0.060) | (0.065) | (0.068) | (0.067) |
| Project site * Borehole use | | | 0.376*** | 0.005 | | | -0.072 | -0.009* |
| * Year 2013 * Distance (km/min.) | | | (0.128) | (0.005) | | | (0.169) | (0.005) |
| Project site/Borehole use (=1) | 0.020 | 0.025 | 0.027 | 0.026 | 0.025 | 0.017 | 0.017 | 0.017 |
| | (0.042) | (0.043) | (0.043) | (0.043) | (0.054) | (0.055) | (0.055) | (0.055) |
| Project site * Borehole non-use | | -0.077 | -0.077 | -0.077 | | -0.039 | -0.039 | -0.040 |
| * Year 2013 (=1) | | (0.069) | (0.069) | (0.069) | | (0.081) | (0.081) | (0.081) |
| Project site * Borehole non-use (=1) | | 0.005 | 0.008 | 0.005 | | 0.050 | 0.050 | 0.050 |
| | | (0.057) | (0.058) | (0.057) | | (0.062) | (0.062) | (0.062) |
| Year 2013 (=1) | -0.074 | -0.075* | -0.075* | -0.074 | -0.036 | -0.034 | -0.033 | -0.032 |
| | (0.045) | (0.045) | (0.045) | (0.045) | (0.052) | (0.052) | (0.052) | (0.052) |
| ***Individual characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Household characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Village characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R sq. | 0.155 | 0.157 | 0.164 | 0.157 | 0.153 | 0.154 | 0.154 | 0.156 |
| No. of observations | 1071 | 1071 | 1071 | 1071 | 1064 | 1064 | 1064 | 1064 |

Note: Village-level cluster-adjusted standard errors are in parentheses: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.
Distance is measured in kilometers in Columns (C) and (G) and measured in minutes in Columns (D) and (H).

## Table 7 Impact on time for schooling and homework (children aged 7 to 18)

| Dependent variable: Time allocation (hours) | Girls | | | | Boys | | | |
|---|---|---|---|---|---|---|---|---|
| | Project | Borehole use | | | Project | Borehole use | | |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) |
| ***Project and year dummy variables*** | | | | | | | | |
| Project site/Borehole use | -0.743 | -0.734 | -1.091* | -0.868 | 0.099 | -0.126 | -0.341 | -0.115 |
| * Year 2013 (=1) | (0.588) | (0.635) | (0.642) | (0.643) | (0.523) | (0.578) | (0.652) | (0.579) |
| Project site * Borehole use | | | 1.632* | 0.029 | | | 1.168 | -0.003 |
| * Year 2013 * Distance (km/min.) | | | (0.937) | (0.022) | | | (1.601) | (0.041) |
| Project site/Borehole use (=1) | -0.055 | 0.081 | 0.089 | 0.085 | -0.003 | 0.143 | 0.139 | 0.143 |
| | (0.386) | (0.421) | (0.421) | (0.421) | (0.417) | (0.429) | (0.429) | (0.430) |
| Project site * Borehole non-use | | -0.758 | -0.758 | -0.757 | | 0.765 | 0.762 | 0.764 |
| * Year 2013 (=1) | | (0.696) | (0.695) | (0.696) | | (0.556) | (0.556) | (0.556) |
| Project site * Borehole non-use (=1) | | -0.454 | -0.441 | -0.451 | | -0.420 | -0.421 | -0.420 |
| | | (0.403) | (0.404) | (0.404) | | (0.521) | (0.521) | (0.522) |
| Year 2013 (=1) | 0.185 | 0.166 | 0.162 | 0.169 | -0.472 | -0.479 | -0.492 | -0.478 |
| | (0.515) | (0.514) | (0.514) | (0.514) | (0.396) | (0.396) | (0.397) | (0.396) |
| ***Individual characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Household characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Village characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R sq. | 0.183 | 0.187 | 0.187 | 0.187 | 0.219 | 0.220 | 0.220 | 0.220 |
| No. of observations | 1021 | 1021 | 1021 | 1021 | 1024 | 1024 | 1024 | 1024 |

Note: Village-level cluster-adjusted standard errors are in parentheses: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.
Distance is measured in kilometers in Columns (C) and (G) and measured in minutes in Columns (D) and (H).

**Table 8 Impact on time for fetching water (children aged 7 to 18)**

| Dependent variable: Time allocation (hours) | Girls | | | | Boys | | | |
|---|---|---|---|---|---|---|---|---|
| | **Project** | **Borehole use** | | | **Project** | **Borehole use** | | |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) |
| ***Project and year dummy variables*** | | | | | | | | |
| Project site/Borehole use | 0.194 | 0.176 | 0.128 | 0.164 | 0.155 | 0.144 | 0.082 | 0.123 |
| * Year 2013 (=1) | (0.186) | (0.192) | (0.199) | (0.194) | (0.132) | (0.145) | (0.147) | (0.144) |
| Project site * Borehole use | | | 0.218 | 0.003 | | | 0.338 | 0.006 |
| * Year 2013 * Distance (km/min.) | | | (0.227) | (0.006) | | | (0.269) | (0.008) |
| Project site/Borehole use (=1) | -0.254* | -0.225 | -0.224 | -0.225 | -0.134 | -0.094 | -0.095 | -0.094 |
| | (0.151) | (0.155) | (0.155) | (0.155) | (0.095) | (0.107) | (0.107) | (0.107) |
| Project site * Borehole non-use | | 0.241 | 0.241 | 0.241 | | 0.170 | 0.169 | 0.171 |
| * Year 2013 (=1) | | (0.230) | (0.230) | (0.230) | | (0.149) | (0.149) | (0.150) |
| Project site * Borehole non-use (=1) | | -0.333* | -0.331* | -0.333* | | -0.253** | -0.253** | -0.253** |
| | | (0.189) | (0.189) | (0.189) | | (0.112) | (0.112) | (0.112) |
| Year 2013 (=1) | -0.650*** | -0.654*** | -0.654*** | -0.653*** | -0.468*** | -0.474*** | -0.478*** | -0.475*** |
| | (0.174) | (0.175) | (0.175) | (0.175) | (0.110) | (0.110) | (0.110) | (0.111) |
| ***Individual characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Household characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Village characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R sq. | 0.147 | 0.148 | 0.148 | 0.148 | 0.128 | 0.131 | 0.131 | 0.131 |
| No. of observations | 1021 | 1021 | 1021 | 1021 | 1024 | 1024 | 1024 | 1024 |

Note: Village-level cluster-adjusted standard errors are in parentheses: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.
Distance is measured in kilometers in Columns (C) and (G) and measured in minutes in Columns (D) and (H).

## Table 9 Impact on fetching water (aggregated to the household level)

| **Dependent variable: Water volume and number of trips** | **Water volume (liters) carried yesterday** | | | | **Number of trips yesterday** | | | | **Number of trips last 1 week** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Project** | **Borehole use** | | | **Project** | **Borehole use** | | | **Project** | **Borehole use** | | |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) | (I) | (J) | (K) | (L) |
| ***Project and year dummy variables*** | | | | | | | | | | | | |
| Project site/Borehole use | 3.874 | 5.612 | 6.142 | 7.281 | 0.402 | 0.502 | 0.516 | 0.548 | 2.509 | 2.571 | 3.276* | 3.279* |
| * Year 2013 (=1) | (5.598) | (5.482) | (5.675) | (5.610) | (0.313) | (0.336) | (0.355) | (0.351) | (1.660) | (1.750) | (1.916) | (1.794) |
| Project site * Borehole use | | | -2.598 | -0.412* | | | -0.070 | -0.011 | | | -3.454 | -0.175* |
| * Year 2013 * Distance | | | (7.871) | (0.212) | | | (0.746) | (0.020) | | | (2.935) | (0.091) |
| Project site/Borehole use (=1) | -0.977 | -1.281 | -1.277 | -1.300 | 0.060 | 0.016 | 0.016 | 0.016 | -0.061 | 0.213 | 0.218 | 0.205 |
| | (5.570) | (5.646) | (5.649) | (5.651) | (0.201) | (0.211) | (0.211) | (0.211) | (1.441) | (1.467) | (1.466) | (1.467) |
| Project site * Borehole non-use | | -2.204 | -2.212 | -2.225 | | 0.052 | 0.052 | 0.051 | | 2.283 | 2.272 | 2.274 |
| * Year 2013 (=1) | | (8.817) | (8.822) | (8.818) | | (0.394) | (0.394) | (0.394) | | (2.125) | (2.125) | (2.126) |
| Project site * Borehole non-use | | 0.056 | 0.053 | 0.037 | | 0.213 | 0.212 | 0.212 | | -1.022 | -1.026 | -1.030 |
| | | (7.190) | (7.192) | (7.195) | | (0.269) | (0.269) | (0.269) | | (1.675) | (1.674) | (1.675) |
| Year 2013 (=1) | -14.88*** | -14.87*** | -14.85*** | -14.85*** | -0.345 | -0.346 | -0.345 | -0.345 | -4.10*** | -4.11*** | -4.08*** | -4.10*** |
| | (4.603) | (4.608) | (4.607) | (4.611) | (0.261) | (0.261) | (0.261) | (0.261) | (1.297) | (1.299) | (1.299) | (1.300) |
| ***Individual characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Household characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Village characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R sq. | 0.086 | 0.079 | 0.079 | 0.081 | 0.051 | 0.049 | 0.049 | 0.049 | 0.077 | 0.078 | 0.079 | 0.080 |
| No. of observations | 1270 | 1270 | 1270 | 1270 | 1270 | 1270 | 1270 | 1270 | 1270 | 1270 | 1270 | 1270 |

Note: Village-level cluster-adjusted standard errors are in parentheses: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.
Distance is measured in kilometers in Columns (C) (G) and (K) and measured in minutes in Columns (D) (H) and (L).

## Table 10 Impact on time for washing/cleaning/cooking (children aged 7 to 18)

| Dependent variable: Time allocation (hours) | Girls | | | | Boys | | | |
|---|---|---|---|---|---|---|---|---|
| | Project | Borehole use | | | Project | Borehole use | | |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) |
| ***Project and year dummy variables*** | | | | | | | | |
| Project site/Borehole use | 0.278** | 0.248** | 0.270** | 0.268** | 0.049 | -0.006 | 0.077 | 0.021 |
| * Year 2013 (=1) | (0.118) | (0.123) | (0.131) | (0.125) | (0.120) | (0.134) | (0.134) | (0.137) |
| Project site * Borehole use | | | -0.099 | -0.004 | | | -0.452*** | -0.007 |
| * Year 2013 * Distance (km/min.) | | | (0.216) | (0.008) | | | (0.171) | (0.008) |
| Project site/Borehole use (=1) | -0.211** | -0.185* | -0.186* | -0.186* | 0.001 | 0.029 | 0.031 | 0.030 |
| | (0.102) | (0.107) | (0.107) | (0.107) | (0.101) | (0.111) | (0.111) | (0.111) |
| Project site * Borehole non-use | | 0.354** | 0.354** | 0.354** | | 0.213* | 0.214* | 0.212* |
| * Year 2013 (=1) | | (0.169) | (0.169) | (0.169) | | (0.123) | (0.123) | (0.123) |
| Project site * Borehole non-use (=1) | | -0.282** | -0.282** | -0.282** | | -0.082 | -0.081 | -0.082 |
| | | (0.129) | (0.128) | (0.128) | | (0.117) | (0.118) | (0.117) |
| Year 2013 (=1) | -0.374*** | -0.377*** | -0.377*** | -0.377*** | -0.259*** | -0.260*** | -0.255*** | -0.258*** |
| | (0.096) | (0.096) | (0.096) | (0.096) | (0.091) | (0.092) | (0.091) | (0.092) |
| ***Individual characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Household characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Village characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R sq. | 0.150 | 0.151 | 0.151 | 0.151 | 0.128 | 0.131 | 0.131 | 0.131 |
| No. of observations | 1021 | 1021 | 1021 | 1021 | 1024 | 1024 | 1024 | 1024 |

Note: Village-level cluster-adjusted standard errors are in parentheses: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.
Distance is measured in kilometers in Columns (C) and (G) and measured in minutes in Columns (D) and (H).

## Table 11 Impact on time for income generating activities (children aged 7 to 18)

| **Dependent variable: Time allocation (hours)** | **Girls** | | | | **Boys** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Project** | **Borehole use** | | | **Project** | **Borehole use** | | |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) |
| ***Project and year dummy variables*** | | | | | | | | |
| Project site/Borehole use | -0.608 | -0.784* | -0.817* | -0.679 | -0.474 | -0.255 | -0.143 | -0.094 |
| * Year 2013 (=1) | (0.404) | (0.418) | (0.439) | (0.421) | (0.365) | (0.407) | (0.449) | (0.440) |
| Project site * Borehole use | | | 0.153 | -0.022 | | | -0.609 | -0.045* |
| * Year 2013 * Distance (km/min.) | | | (0.503) | (0.020) | | | (0.645) | (0.024) |
| Project site/Borehole use (=1) | -0.036 | 0.008 | 0.009 | 0.005 | -0.183 | -0.153 | -0.152 | -0.152 |
| | (0.178) | (0.194) | (0.194) | (0.193) | (0.168) | (0.186) | (0.186) | (0.186) |
| Project site * Borehole non-use | | -0.162 | -0.162 | -0.162 | | -1.211*** | -1.210*** | -1.218*** |
| * Year 2013 (=1) | | (0.567) | (0.567) | (0.568) | | (0.414) | (0.414) | (0.414) |
| Project site * Borehole non-use (=1) | | -0.131 | -0.130 | -0.134 | | -0.282 | -0.281 | -0.285 |
| | | (0.261) | (0.261) | (0.261) | | (0.260) | (0.260) | (0.261) |
| Year 2013 (=1) | 0.641* | 0.638* | 0.637* | 0.635* | 0.503* | 0.481* | 0.487* | 0.490* |
| | (0.329) | (0.329) | (0.329) | (0.328) | (0.266) | (0.266) | (0.267) | (0.266) |
| ***Individual characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Household characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Village characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R sq. | 0.232 | 0.236 | 0.235 | 0.236 | 0.281 | 0.288 | 0.289 | 0.291 |
| No. of observations | 1021 | 1021 | 1021 | 1021 | 1024 | 1024 | 1024 | 1024 |

Note: Village-level cluster-adjusted standard errors are in parentheses:; * Significant at 10%, ** Significant at 5%, *** Significant at 1%.
Distance is measured in kilometers in Columns (C) and (G) and measured in minutes in Columns (D) and (H).

## Appendix 1: Balance test

| | Project sites | Control sites | Difference |
|---|---|---|---|
| | (A) | (B) | (C) |
| ***Individual characteristics*** | **n=2239** | **n=1065** | |
| Female (%) | 51.8 | 50.0 | 1.9 |
| Age | 20.9 | 20.7 | 0.2 |
| Aged 0 to 6 (%) | 22.8 | 25.4 | -2.7* |
| Aged 7 to 18 (%) | 34.1 | 30.9 | 3.2** |
| Aged 19 to 59 (%) | 39.3 | 40.3 | -0.9 |
| Aged 60 and above (%) | 3.8 | 3.4 | 0.4 |
| **Working age females aged 19 to 59** | **n=459** | **n=217** | |
| Education (years of schooling) completed | 5.483 | 4.764 | 0.719*** |
| Crop farmers (%) | 79.5 | 77.4 | 2.1 |
| Fishery workers (%) | 0.0 | 0.5 | -0.5 |
| Traders/retail shopkeepers (%) | 4.8 | 6.9 | -2.1 |
| **Working age males aged 19 to 59** | **n=422** | **n=212** | |
| Education (years of schooling) completed | 6.895 | 6.700 | 0.196 |
| Crop farmers (%) | 72.5 | 71.7 | 0.8 |
| Fishery workers (%) | 4.7 | 3.3 | 1.4 |
| Traders/retail shopkeepers (%) | 3.1 | 3.8 | -0.7 |
| ***Household characteristics*** | **n=429** | **n=206** | |
| Female headed household (%) | 20.0 | 19.9 | 0.14 |
| Age of the head | 43.4 | 42.3 | 1.18 |
| Household size | 5.219 | 5.170 | 0.049 |
| Ratio of dependents to household size | 0.452 | 0.453 | -0.002 |
| Monthly consumption per capita (thousand ZMK) | 162.4 | 143.2 | 19.2 |
| Value of durable assets (million ZMK) | 1.394 | 1.366 | 0.029 |
| Agricultural land value (million ZMK) | 3.362 | 5.138 | -1.776* |
| ***Village characteristics*** | **n=63** | **n=31** | |
| Population (households) | 98.2 | 97.6 | 0.61 |
| Population (individuals) | 480.6 | 439.8 | 40.7 |
| Land area (ha) | 141.4 | 98.4 | 42.9 |
| Flat villages (%) | 31.7 | 38.7 | -7.0 |
| Slightly sloping villages (%) | 38.1 | 35.5 | 2.6 |
| Moderately sloping villages (%) | 28.6 | 22.6 | 6.0 |
| Steeply/hilly villages (%) | 1.6 | 3.2 | -1.6 |
| Average asset per household* (million ZMK) | 5.940 | 7.071 | -1.131 |
| Distance to district center (km) | 45.4 | 36.4 | 8.9 |
| Distance to town center (km) | 26.5 | 15.8 | 10.7 |
| Distance to market (km) | 12.3 | 13.2 | -0.9 |
| Distance to government primary school (km) | 2.0 | 2.7 | -0.7 |
| Distance to government secondary school (km) | 29.2 | 30.8 | -1.6 |
| Distance to rural health center (km) | 7.3 | 9.5 | -2.2 |

Note: t-test or Fisher's exact test results are shown:; * Significant at 10%, ** Significant at 5%, *** Significant at 1%.
Monthly consumption per caipta is adjusted by using adult equivalence scales and measured in the real team at the price level of 2012. Asset per hosuehold includes the value of residence, residential and agricultural land, and duarable assets. 1USD was approximately 5200ZMK as of June 2012.

## Appendix 2: Impact on time for water-related household chores [a)] (working-age adults 19 to 59 living with children 3 to 18) [b)]

| Dependent variable: Time allocation (hours) | Female adults aged 19 to 59 | | | | Male adults aged 19 to 59 | | | |
|---|---|---|---|---|---|---|---|---|
| | Project | Borehole use | | | Project | Borehole use | | |
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) |
| ***Project and year dummy variables*** | | | | | | | | |
| Project site/Borehole use | -0.418 | -0.622** | -0.693* | -0.744** | -0.086 | -0.048 | 0.001 | -0.035 |
| * Year 2013 (=1) | (0.279) | (0.307) | (0.350) | (0.323) | (0.121) | (0.125) | (0.136) | (0.125) |
| Project site * Borehole use | | | 0.309 | 0.026* | | | -0.251 | -0.004 |
| * Year 2013 * Distance (km/min.) | | | (0.472) | (0.015) | | | (0.284) | (0.007) |
| Project site/Borehole use (=1) | 0.156 | 0.323 | 0.325 | 0.326 | 0.067 | 0.021 | 0.020 | 0.020 |
| | (0.243) | (0.258) | (0.259) | (0.258) | (0.123) | (0.124) | (0.124) | (0.124) |
| Project site * Borehole non-use | | 0.166 | 0.166 | 0.167 | | -0.189 | -0.189 | -0.190 |
| * Year 2013 (=1) | | (0.389) | (0.389) | (0.390) | | (0.245) | (0.245) | (0.245) |
| Project site * Borehole non-use | | -0.314 | -0.312 | -0.310 | | 0.217 | 0.215 | 0.216 |
| | | (0.310) | (0.310) | (0.311) | | (0.231) | (0.232) | (0.232) |
| Year 2013 (=1) | -1.072*** | -1.080*** | -1.082*** | -1.079*** | -0.191** | -0.189** | -0.188** | -0.189** |
| | (0.251) | (0.252) | (0.252) | (0.251) | (0.091) | (0.091) | (0.091) | (0.091) |
| ***Individual characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Household characteristics*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| ***Village variables*** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R sq. | 0.215 | 0.222 | 0.222 | 0.224 | 0.176 | 0.179 | 0.179 | 0.179 |
| No. of observations | 840 | 840 | 840 | 840 | 791 | 791 | 791 | 791 |

Source: Table 8 of Shimamura et al. (2020).

Note: Village-level cluster-adjusted standard errors are in parentheses: * Significant at 10%, ** Significant at 5%, *** Significant at 1%. Distance is measured in kilometers in Columns (C) and (G) and measured in minutes in Columns (D) and (H).

a) Water-related household chores comprise fetching water, washing, cleaning, and cooking.

The sample is confined to working-age adults aged 19 to 59 who live together with children of the same gender aged 3 to 18.